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Three Thousand Ton Molding Press at the Creusot Iron Works, France.—(See page 56).

The Properties of Selenium and Their Applications in Electrotechnics—II

By Erich Hausmann, Sc.D.

Continued from Supplement No. 1881, page 45.

INERTIA OF SELENIUM CELLS.

It has long been known that the increase in electrical conductivity of selenium resulting from illumination is not instantaneous and that the recovery of its original resistance after exposure is considerably slower. This phenomenon is known as inertia or fatigue. On illuminating a cell, the greater part of the diminution of

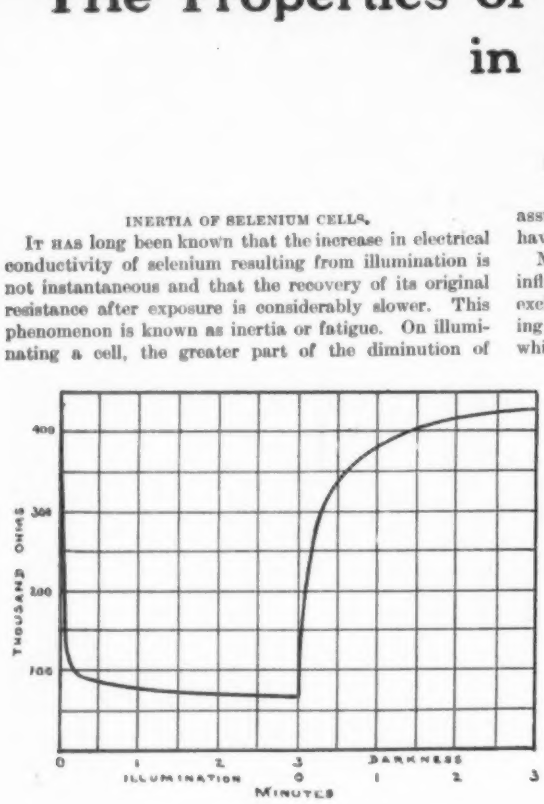


Fig. 5.

resistance occurs during the first second, but the action in not generally considered complete until the expiration of the following five or ten minutes. The results of tests on the inertia of selenium for two cells are given in the following tables:

TABLE V.—CELL B.

(Dark resistance = 100,000 ohms.)

Upon sudden illumination.		Upon sudden darkening.	
Time.	Resistance.	Time.	Resistance.
1 sec.	52,500	0 sec.	32,000
2 "	42,000	5 "	45,000
3 "	39,000	1 min.	52,500
1 min.	36,600	2 "	55,500
2 "	35,700	5 "	60,000
4 "	33,000	10 "	66,000
5 "	32,000	15 "	70,000

A constant illumination of 100 luces was obtained with a 16 candle-power lamp at 40 centimeters distance from the cell.

TABLE VI.—CELL C.

Upon sudden illumination.		Upon sudden darkening.	
Time.	Resistance.	Time.	Resistance.
0 sec.	437,000	0 sec.	70,000
3 "	112,000	3 "	175,000
10 "	93,000	10 "	260,000
30 "	81,000	30 "	344,000
1 min.	75,000	1 min.	385,000
2 "	72,000	2 "	418,000
3 "	70,000	3 "	429,000

A constant illumination of 100 luces was obtained with a standard 16 candle-power electric lamp at a distance of 40 centimeters from the selenium cell. The resistances of this cell were determined by means of a suitable current-measuring device on a 60-volt circuit, and are shown in Fig. 5.

That the decrease in the conductivity of selenium upon darkening is not an instantaneous effect was probably first observed by Kalischer, who also showed that the recovery was dependent upon the duration and intensity of the previous exposure. Some cells must be kept in the dark for several hours before the resistance again assumes its initial value; and indeed some investigators have extended the time required to from 2 to 3 days.

Measurements of the recovery of selenium cells, as influenced by the duration and intensity of the previous excitation, have been made by Merritt[1], and the following curves (Fig. 6) embody his results for exposures to white light of 10, 30, and 300 seconds. A cell having a

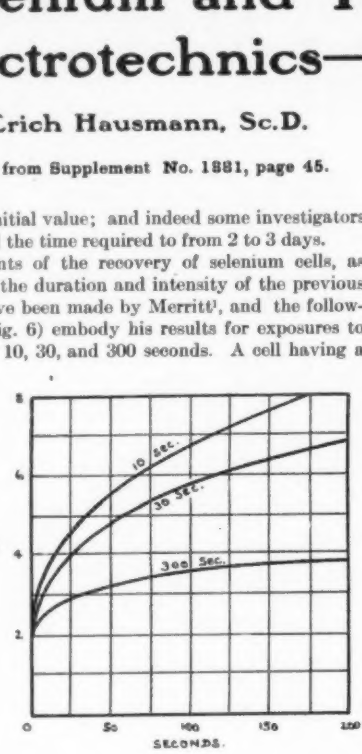


Fig. 6.

dark resistance of 50,000 ohms was placed in circuit with a dead-beat galvanometer and a battery of 1 volt, and was excited by an acetylene flame at a distance of 40 centimeters. The ordinates of the curves are an inverse function (the reciprocal of the square root) of the change in conductivity. From an inspection of the figure it is seen that the recovery is more rapid for the shorter exposures. Curves of recovery under the same exposure with change in intensity of illumination are of similar shape, and show that the recovery is more rapid for the lower illuminations.

Recovery is slower for excitation by infra-red light than by light of the visible spectrum, but the relative time of recovery after exposure to different wavelengths varies with the individual cells. The relative time of recovery of the initial dark resistance (60,000 ohms) of a certain selenium cell of the Bidwell type, for equal exposures to light of different wave-lengths is

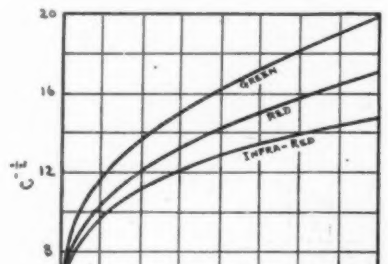


Fig. 7.

shown in Fig. 7. These curves start from the same initial value of the ordinate so that a comparison may be effected; the ordinates employed are again the reciprocals of the square root of the change in selenium conductivity.

CONSTRUCTION OF SELENIUM CELLS.

As previously stated, the resistance of selenium is very high; therefore, in order to facilitate experimentation therewith, it is necessary to put this material in such form that only a short length (but of large cross-sectional area) of it need be traversed by the current. A further condition is that the selenium must be in a very thin layer so that a comparatively large surface may be influenced by light with respect to its volume. This is necessary because the exposed portion only of the selenium will experience alteration of resistance upon illumination.

Werner Siemens, in 1875, first constructed selenium cells with these conditions in view. They were usually made by winding two separate lengths of wire, either of copper, brass, or platinum, equidistant throughout their length upon such substances as slate, glass, mica, or porcelain. The selenium was then spread thinly over the wires, forming a bridge between their terminals. The cells were then exposed to a temperature of about 210 deg. C. for several hours and subsequently allowed to cool gradually. This process of long heating and slow cooling is known as "annealing."

There are a number of types of selenium cells at present in use, among which are those designed by Bidwell, Ruhmer, Pfund, and Giltay.

The Bidwell cell consists of a tablet of glass, mica, or slate, 1.7 x 5.5 centimeters, about which are wound two copper wires (0.2 millimeter diameter) in the form of a double screw; the wires being about 0.8 millimeter apart. Fig. 8 shows the arrangement. The wires constitute the electrodes, and great care must be exercised that they do not touch each other, which may easily occur during the heating process.

In order to apply the selenium, the wire-wound strip is laid on a brass plate (but separated therefrom by a thin sheet of mica) under which may be placed a Bunsen burner. One surface of the strip is evenly covered with somewhat less than a gram of powdered selenium, and upon the application of heat, the greater part of it will melt, but some of it will crystallize in hard gray lumps; thus necessitating continued heating until these disappear. The flame should be adjusted so that the temperature is only just above the melting point, 217 deg. C., at which temperature the selenium assumes a plastic semi-fluid condition and can be easily manipulated with a steel spatula to yield a uniform coating on the strip. When a satisfactory surface is secured, the cell is transferred to a thick copper plate to cool quickly.

The flame having been lowered to yield a temperature of approximately 120 deg. C., the cell is replaced upon the hot plate, and after a few minutes the black, lustrous surface will change to a dull gray color. The temperature is then cautiously raised until signs of melting appear, and when this occurs, the flame is withdrawn and the darkened spot will soon recrystallize. The burner is then replaced with a slightly smaller flame and left for four or five hours, during which time the temperature of the selenium should be only a few degrees below its melting point. Another hour is required in slowly cooling the cell, the flame being gradually lowered.

The resistance of a cell constructed carefully in this manner generally lies between 50,000 and 100,000 ohms in the dark and may have a sensibility of from 4 to 10.

Improvements upon this method of construction have enabled Ruhmer to manufacture cells of considerably higher sensibility. The grid for his cells are of porcelain or lava, and are made in two parts which permit of a slight separation to take up the expansion of the wires, and thereby eliminating possible short-circuits.

A form of selenium cell particularly adapted for light-telephony is Ruhmer's cylindrical cell, for these, if placed in the optical axis of a parabola reflector, may receive uniform illumination over their entire surface. They are mounted in glass bulbs from which the air has been exhausted, a screw base being provided which is similar to those on commercial incandescent lamps. The advantage secured by enclosing the cell in a vacuum is the constancy of resistance for definite illumination, for the resistance of a selenium preparation gradually alters with time, and loses its sensitiveness to light. This effect has been attributed to the formation of selenides at the electrodes. The absorption of moisture by the selenium is prevented in this type of construction.

This investigator has found that two types of cells may be prepared, called by him "hard" and "soft" cells, their difference in behavior being due to the allotropy of crystalline selenium. A soft cell is coarse-grained and may be obtained by annealing at a temperature of 200 deg. C., followed by cooling, whereas a hard cell is fine-grained, and may be obtained by annealing at a somewhat lower temperature and followed by more

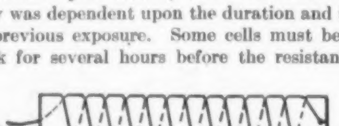


Fig. 8.

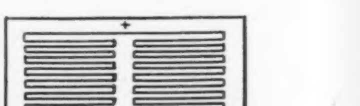


Fig. 9.

[1] Phys. Rev., v. 25, p. 502.

rapid cooling. Hard cells have a greater resistance than soft ones, and suffer a relatively smaller change in resistance to weak illumination than the other type. The soft cells are very sensitive for low light intensities, but their resistance change when exposed to strong illuminants is small compared to that of the hard cells. Compare resistances of Cell A (soft) and Cell B (hard) given in Tables I and II. A longer time is required by a hard cell to assume its ultimate resistance value upon exposure to light than by soft cells. The gain of resistance on cutting off light is slower for soft than for hard cells.

A reliable method of selenium cell construction, although not yielding cells of the highest sensibility, is given by Pfund. A piece of plane glass, 3 x 1 centimeters and 1 millimeter thick, is ground on one face and some purified amorphous selenium is applied thereto by means of a hot glass rod. The thickness of the layer should be such that it will appear deep ruby red in transmitted light. Four separate wires (0.01 inch diameter) are simultaneously wound around the cell to cover the entire surface, but two alternate wires are thereafter removed, thus leaving a space equal to the diameter of the wire between the two remaining ones. The cell is then placed in an air-bath, previously heated to 180 deg. C., to remain for a few minutes until the transformation from amorphous to metallic selenium has taken place. It is then withdrawn and allowed to cool. Such cells have resistances of about 20,000,000 ohms in the dark, and their resistance under an illumination of 180 luces is about one-tenth of this value.

Reinganum and Gripenberg have described methods of constructing selenium cells employing selenium vapor. Two long furrows are etched on a glass plate at a small distance apart and filled with platinum, after which the plate is exposed to selenium vapor, care being taken that it does not become too hot. Caution must be observed owing to the exceedingly poisonous nature of the red vapor of selenium. Cells of this kind cannot be short-circuited, and may be constructed to have a small resistance with respect to their size.

A simple method of constructing selenium cells consists of coating one side of a glass plate with silver, and tracing thereon a fine line dividing the plate into two electrically distinct portions, as illustrated in Fig. 9.

The selenium is then applied to the metal side in a manner similar to those already described. In this type, the distance between electrodes may be made extremely small, and the resistance between any two points across the selenium is more nearly constant. The effects of radiations of particular wave-lengths, such as ultra-violet light, etc., cannot be investigated with this type of cell since glass is opaque to these rays.

THEORY OF RESISTANCE CHANGE IN SELENIUM DUE TO LIGHT.

Two principal views of the cause of resistance change of selenium under the influence of light have been proposed. The first given by Siemens, ascribes the effect to the allotropic dissociation of selenium, and the second, due to Bidwell[1], refers it to the formation of selenides at the junctions of the selenium with the metallic electrodes, upon the incidence of light.

The theory of Bidwell is based upon the following facts: 1, the conductivity of selenium is of electrolytic character; 2, selenium is a poor conductor, whereas selenides are fairly good conductors; and 3, light assists the formation of the selenides while operating.

It was shown before that the light effect is attributable to the selenium itself and not to its selenides, and as the experiments of Berndt have shown that reduction in resistance cannot be explained as due to chemical processes (since he used inert carbon electrodes), it becomes necessary to discard the theory of Bidwell in favor of the first mentioned one.

Gray crystalline selenium exists in two modifications as discussed in Part I, from which it appears that Se_α is practically a non-conductor, and Se_β a good conductor of electricity. Both of these forms are probably present in every cell, and the influence of light thereon is held to change the mass-equilibrium of these forms, or in other words some of the Se_α is transformed into Se_β, thereby changing the electrical resistance of the cell. The establishment of an equilibrium between the α and β forms of selenium is greatly accelerated by the presence of metallic catalytic agents, especially silver and platinum; even so small an amount of silver as 0.03 per cent being effective.

To explain the resistance change in selenium, Brown[2] supposes the existence of three allotropes in equilibrium, only one of which is electrically conducting. His experiments show that the change of conductivity at any instant is due to the amounts of the changing components and to the alteration of the rates of interchange between these components: This theory also permits the explanation of the behavior of the infrequent light-negative variety of selenium, which decreases its conductivity upon exposure to light.

To be continued.

[1] *Phil. Mag.*, v. 20, p. 178; v. 40, p. 233.

[2] *Phys. Rev.*, v. 33, p. 1,403, 1910.

The Kola Tree and Its Seed

A Plant of Varied Utility

AMONG those remarkable plants which have come to be recognized as providing "the cup that cheers but not inebriates," perhaps the most interesting of all is the kola tree.

Like tea, coffee, cocoa, and matè, the kola-nut owes its refreshing and stimulating qualities chiefly to the presence of caffein. But not only is there a much larger percentage of this substance than in tea or coffee, but there is present also a considerable quantity of "cola-red."

The latter is a mixture of alkaloids which acts on the muscular system, while caffein acts only on the nervous system.

In modern therapeutics kola is regarded as highly efficacious in preventing fatigue and drowsiness, in increasing the amount of energy liberated or work done, and as a heart stimulant. It increases and regulates the appetite, and enables the debilitating effect of tropical climates to be better withstood. It has some diuretic value, and has a tonic effect on the intestines, being used as a remedy for diarrhœa and certain fevers.

The kola-nut, as it is known in common parlance, though strictly speaking it is not a nut but a seed, is most powerful in its fresh condition, since it then contains an oil of stimulating properties, which augments its action. This oil is destroyed by dessication, and is therefore absent in the dried nuts which are imported into Europe and America in a quantity of about 1,000 tons yearly. Since the estimated annual introduction throughout the world is 20,000 tons of the fresh nuts, it will be seen that its merits are enthusiastically appreciated in its own habitat.

The tree is a native of the west coast of Africa, where it grows wild from Sierra Leone to the Congo, extending some 500 miles inland. It is also cultivated, and has been transplanted into various parts of the world where there are many negroes, such as the West Indies, Mexico, and Brazil.

Although travelers' accounts of its wonderful properties were extant in Europe as early as the sixteenth century, little was known of it till the nineteenth and the first thorough study of its properties was made in 1883 by Prof. Heckel of Marseilles and Prof. Schlagdenfauffen of Nancy.

Various botanists have studied and described the characteristics of the tree, but probably a large amount of knowledge as to the best methods of cultivation, the increase of yield, and the protection from insect and fungus enemies which are numerous is yet to be gleaned, and this could be best done in suitable botanical gardens or experiment stations.

The most comprehensive work on the tree and its fruit is a new book by M. M. Chevalier and Perrot, called "Les Kolatiers et les noix de Kola" (A. Challamel, Paris, May, 1911).

The authors made extensive observations in Africa, and the volume not only contains highly valuable scientific information, but throws a curious side light on social customs.

The kola tree belongs to the genus *Malvacea* of the family *Sterculacea*. The height varies from thirty to sixty feet, and the growth is slow, about fifteen years being required for the tree to come into full bearing, while the natives estimate the duration of its life as that of four human generations—about 120 years.

The leaves are single, simple, lanceolate, and acuminate, and are glabrous and coriaceous. The leaf-stems have the property of twisting, the motion being governed by the intensity of the light, obviously a highly useful quality under a tropical sun.

The flowers are borne in clusters and are of a creamy white, stained with dark purple at the bottom. They are small and apetalous. The same plant usually bears both male flowers and polygamous, but M. M. Chevalier and Perrot call attention to the curious fact that when grown in unfavorable conditions, such as heavy shade or at an altitude of more than 800 meters above sea-level, the *Cola Nitida* produces only male flowers.

The fruit has a brown leathery rind and contains from 1 to 12 seeds. These are about the size and shape of a chestnut, though more elongated. They are covered with a white skin which the natives remove after gathering. What is known commercially as the Kola-nut is this seed, stripped of the integument, and consisting of the naked embryo, which is exalbuminate. The thick and fleshy cotyledons vary from 2 to 7, but the *C. Nitida* has only 2. The nut is either red or white, occasionally showing a greenish or yellowish pink tint. The maximum annual yield under good conditions is about 10 kilogrammes per tree, or some six or seven hundred nuts, and this amount is the average consumption of a negro habituated to the use of the nut.

The taste of the fresh nut is bitter-sweet and aromatic, and that of the dried nut similar, though not quite the same. The percentage of caffein varies, but is over 2 per cent in the best specimens.

The close association in the minds of primitive races between religion and the art of healing, and the fact that the functions of priest and healer are usually united in the same individual makes it easy to understand why plants possessing beneficent or medicinal qualities should be considered both divine in origin and mystically sacred in character.

This tendency in human nature is strikingly illustrated in the attitude of natives of Africa toward the kola-tree. The nut is used as an amulet, as a token of love, or a gage of friendship. It is eaten with ceremonious solemnity in the taking of an oath as a fetichistic test of good faith. It is likewise an offering to divinities and in Dahomey there is the custom, rather startling to the European mind, of doing homage by crushing the nut in the teeth and expectorating the chewed mass upon the idol!

The eating of it by friends is a binding rite of brotherhood, like the eating of salt among the Arabs or the exchange of blood. If the host possesses only a single nut, the laws of hospitality exact that he shall break it with his teeth into as many pieces as there are guests.

It is used also as a betrothal or marriage gift, and in some parts of Africa, if a man desires a maiden to wife, he sends her father a basket of red and of white kola-nuts. If the suitor is accepted the gift is kept, otherwise the red nuts are returned.

The nuts are also used as a medium of exchange and for paying tribute.

Chevalier relates an amusing anecdote to illustrate the sacredness of the tree itself. "Finding ourselves," he says, "in 1899 in a little village near Kankan, where there was a superb kola tree in flower, we demanded permission from the chief man of the village to cut a branch for our studies. Great excitement! The chief did not want to refuse, but he didn't dare permit it! Not wishing to decide it himself, he called a council of certain old men together with representatives of the family to which the tree belonged. After a long palaver it was decided that in my character of a European I might venture to take away the specimens desired, but I must make the cut myself, nobody daring to perform this operation, and all the assistants swearing by Allah that they were not responsible for the evils which would without doubt befall me."

In this country and Europe kola is used as an alcoholic extract or tincture, a wine, an ingredient of some beverage or medicine, a powder, or mixed with other things, such as sugar and chocolate. In view of its specific physiologic action, manufacturers who use it as a constituent of either food or medicine should be required to state the percentage used, as well as the fact of its presence.

Motion Pictures for Selling Machinery.

"To bring a machine to the buyer's office and to show it in action without the noise and grime of the factory is virtually what is suggested by the Motionscope Company, Indianapolis, Ind.," says the *Iron Age*. "The company manufactures a motion-picture machine of a size fitting into a salesman's traveling case, but in addition to enabling the salesman to enter a prospect's office and give a demonstration of the machine in operation, it is pointed out that films may be shipped to prospective buyers when it may not be necessary to send the entire machine. Then the film can be shown at the regular motion-picture institution of the neighborhood at little cost.

"The picture machine is equipped with an attachment for showing single slides, which of course may be colored or may be reproductions of drawings to elucidate features of the design not conveniently explained with the motion picture. Of course, with a motion-picture machine the reels may be stopped at any point and a definite operation studied with care. The possibilities of the application of the motion-picture machine are of course great, and it is interesting to add that the company has had such a degree of success in introducing the machine that it contemplates the erection of a plant of double the present capacity for turning out films, slides and picture machines. It has prepared an illustrated booklet covering at length the argument for the use of the motion picture for machine selling."

Fig. 1.—Ramie Fibers. (Magnified 75 Times.)

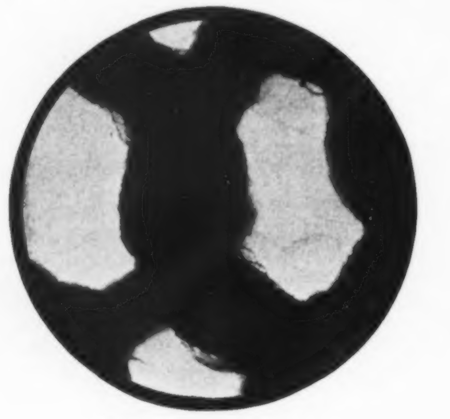


Fig. 2.—Cotton Fibers.

Fig. 3.—Artificial Silk Fibers.

Incandescent Gas Mantles of Artificial Silk

An Important Application for the Synthetic Fiber

IT was discovered in the infancy of the incandescent gas light, that the quality of an incandescent mantle depends largely on the nature of its fibrous material, and attempts were made to find a better material than cotton which, at first, was used exclusively. Ramie fiber was first employed on a large scale, in the production of gas mantles, by Buhlmann, in 1908. Ramie is much rougher than cotton, as is shown by the micro-photographs of the two fibers. (Figs. 1 and 2.) Hence a ramie mantle possesses a larger radiating surface and emits more light than a cotton mantle of the same size. Ramie mantles present the additional advantage of being less deformed by heat than cotton mantles, which soon lose their original form and, with it, part of their luminosity. Although the ramie mantle was at first unpopular because of its rough and unsightly appearance, it is now used, in Germany at least, far more extensively than the cotton mantle.

Hemp, jute and other vegetable fibers have been tried as materials for gas mantles, but with unsatisfactory results. On the other hand, artificial silk threatens to drive ramie from the field, according to a writer in *Prometheus*. Experiments with artificial silk have been carried on persistently since the beginning of the present century. Until recently no thoroughly satisfactory results were obtained, a chief obstacle being the fragility of the artificial silk mantles, which made them unsuitable for transport. Now, however, it is possible to purchase artificial silk mantles which are far superior to the best ramie mantles. These artificial silk mantles, as Fig. 3 shows, are even rougher that ramie mantles, the fibers being more subdivided, so that the radiating surface and the luminosity are correspondingly increased. They are far more durable than ramie mantles, owing to the great strength and elasticity of the artificial silk fibers. This durability is illustrated by Figs. 4, 5, and 6, which show the condition of "Degea" artificial silk mantle after 250, 500, and 1,000 hours' use. Even in the last case the individual fibers remain intact, while many fibers of a ramie mantle which has been used 1,000 hours are broken and destroyed, as is shown by Fig. 7. Hence artificial silk mantles are especially desirable for use with compressed gas, for street lamps, and in every case where durability is a chief requisite.

The introduction of artificial silk not only improves the quality of the incandescent gas mantle, but also greatly simplifies its production. In the manufacture of cotton and ramie mantles one of the most important operations consists in washing out all impurities, which would seriously impair the quality of the product. These tedious and costly washings are not required with artificial silk, as this material already possesses the required degree of purity.

The *Annalen fuer Gewerbe und Bauwesen* furnishes the following additional information:

All incandescent gas mantles are impregnated with a solution of the nitrates of thorium and cerium. The fibrous material of the mantle is then burned away, leaving a skeleton composed of the oxides of these metals, whose radiating power is far superior to that of carbon. The fragile skeleton mantle is then dipped in collodion in order to make it strong enough for shipment. It is the gun-cotton deposited by the collodion, and not the original textile fabric that is burned off when the mantle is first lighted by the consumer.

In the first experiments with artificial silk mantles the nitrates of thorium and cerium were added to the ammonia-copper-cellulose solution, from which the fibers of artificial silk were formed by injecting the viscous solution through small orifices into dilute acids. The result was not satisfactory, and now artificial silk, like other fibers used for mantles, is first woven into tubes, which are then bathed in the thorium and cerium solution. This operation reveals an essential difference between vegetable fibers and artificial silk. The former are composed of cells separated by partitions. The cells alone are filled with the metallic solution and under the microscope the fiber shows the same discontinuous structure which it exhibited before the bath. The indefinitely long, wire-like fibers of artificial silk, on the contrary, swell in the bath, like glue in cold water, become uniformly saturated

Fig. 4.—Artificial Silk Mantle After 250 Hours' Use.

Fig. 5.—Artificial Silk Mantle After 500 Hours' Use.

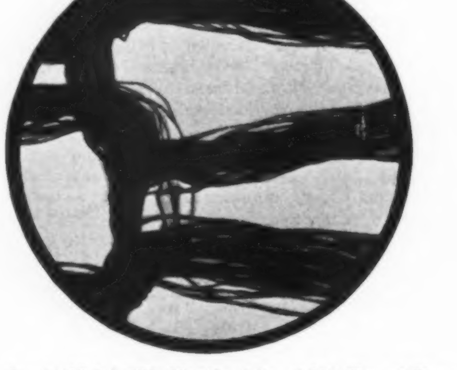


Fig. 6.—Artificial Silk Mantle After 1,000 Hours' Use.

Fig. 7.—Ramie Mantle After 1,000 Hours' Use.

Fig. 8.—Mantle Supporting 250 grammes after 500 hours' use.

Fig. 9—Mantle After 100 Hours' Use and 2,000 Shocks.

Fig. 10.—Artificial Silk Mantle After 7 Weeks' Use in a Street Lamp.

Fig. 11.—Ramie Mantle Deformed and Broken by Explosive Lighting.

with the solution through their whole mass, and remain slightly swollen after drying. The bath is followed by other treatments which are kept secret by the various manufacturers.

repeated shocks and vibrations. Good ramie mantles, tested in this machine, endure from 500 to 1,000 shocks before they have been used, but only 100 shocks after burning 10 hours, while "Bamag" artificial silk mantles

this way a weight of 300 grams when new, and 225 grams after 500 hours' use. Inverted "Bamag" mantles, used with compressed gas for street lighting, have been found almost uninjured after seven weeks' use, in conditions in which the best ramie mantles last only six nights. "Bamag" mantles of this type consume less than half the gas required by ramie mantles, and show an average durability of 200 shocks after one hour's use, when tested on the Drehschmidt machine.

Fig. 9 shows a "Bamag" mantle of the ordinary type after 100 hours' use, followed by 2,000 shocks.

A "Bamag" inverted mantle which had burned 24 hours (Fig. 12) was introverted (Fig. 13) and restored to its original form (Fig. 14) without injury. Fig. 10 shows one of the street lamp mantles mentioned above, after 7 weeks' use. The mantle is intact, though the burner has suffered and has deposited a quantity of iron oxide in the bottom of the mantle.

Fig. 11 shows the permanent deformation and holes produced in a ramie mantle by the explosive lighting of highly compressed gas. In these conditions the artificial silk mantle simply expands without injury.

The durability of artificial silk mantles is due largely to the great length of the fiber, which does not, like the short vegetable fibers, untwist and fray in the heat of the flame.

Figs. 12, 13, and 14.—A Mantle Purposely Deformed and Restored After 24 Hours' Use.

The new "Bamag" artificial silk mantles combine extraordinary strength with a luminosity equal to that of good ramie mantles. Prof. Drehschmidt has invented a machine for testing the durability of a mantle under

withstand 6,000 shocks before use and 600 shocks after burning 500 hours. The mantles are so tough that they can be loaded with weights clamped to their lower edges, as is shown in Fig. 8, and can support in

The Earning Power of Chemistry*

The Bessemer Process Has Added Two Billion Dollars Yearly to the World's Wealth

By Arthur D. Little

It may fairly be claimed for chemistry that it is at once the most fundamental and the most comprehensive of all the sciences. Its province, in the classical definition of Ostwald, is "The study of the different forms of matter, their properties, and the changes which they undergo." Thus defined, chemistry embraces the material universe, our solar system, the most distant stars and the flaming nebulæ no less than the dust speck within the universe, on which we live and which we call the earth. It includes within its subject matter the physical basis of our own bodies and of those of every living thing upon the earth. It is directly concerned with the air we breathe, the water we drink, the food we eat, the materials upon which we expend our labor, and the things which we buy and sell.

To me has been assigned the pleasant task of bringing home to you some conception of the extent to which you are already indebted to this science and a better appreciation of the comprehensive benefits which it still holds out to you.

The world in which we live is a different world to every individual in it, as it has been a different world to every generation of the race of men. To no other generation have its confines been so opened out and broadened as to our own. To the man congenitally blind, tapping his way along the curb, a modern city is a place of sounds and measured spaces; to one who sees, it becomes a world of light and movement and ever-changing shades. Plymouth Rock is a very ordinary piece of granite to one who knows not its history; to the better informed it stands as the symbol of that adventurous spirit and uncompromising virtue on which the foundations of our country rest. To the world at large coal-tar is a black and evil-smelling nuisance; to the eye of the chemist it is replete with all the potentialities of the rainbow.

So it happens that the world as viewed by the chemist presents an aspect different in many ways from that in which it appears to the mind not chemically trained. As the astronomer perceives in the movements of the stars a relationship and co-ordination to which the average man is blind, and deduces from them generalizations by which both the intellectual and practical life of the community are profoundly influenced, so the chemist, who may be regarded as the astronomer of the infinitely minute, studies the movements and interchange of atoms and the structure of the molecular systems which result therefrom. In other words, the astronomer interprets the universe in terms of certain units, which are the heavenly bodies, while the chemist seeks his interpretation in terms of the ultimate particles of which matter is composed, whether they be molecules, atoms, ions or electrons. And, since the different forms of matter, in their flux and flow, together constitute the universe, the properties of matter and the changes which these properties undergo are of compelling interest and importance to each one of us in every activity of our lives.

We live immersed in an ocean of air and we draw this air into our lungs approximately eighteen times a minute. The quality of this air, its temperature, pressure, humidity, the minute impurities which may be present, affect our comfort and well-being in many ways. It supports the chemical processes of combustion by which our existence is maintained no less than those upon which we are chiefly dependent for light and heat and power. The nature of this all-enveloping atmosphere of air has always been a subject of speculation, though to little purpose before the advent of chemistry.

Modern chemistry had its birth in the eighteenth century study of the air and its relation to the processes of respiration and combustion. Prof. Ramsay has said that "To tell the story of the development of men's ideas regarding the nature of atmospheric air is in great part to write a history of chemistry and physics." The story is one which has reached its culminating interest in our own most recent times. For $35 you may now buy apparatus for reducing air to the liquid form and study the properties of matter at temperatures nearly as low as that of interstellar space.

Within the memory of the youngest undergraduate in chemistry the brilliant researches of Ramsay, Raleigh and other chemists have disclosed the presence in the air we breathe of five new gases of remarkable and in some respects unique properties. To one of these, neon, we now confidently attribute the long mysterious phenomena of the aurora borealis. Tubes containing highly rarefied neon may become as commonplace to our descendants as candles were to our forefathers. They glow with a rich, mellow, golden light on the passage through them of an electrical discharge.

The heavy toll of life in mine disasters would be unsupportably heavier were it not for the Davy lamp, the fire-damp indicators, the rescue outfits and the regulation of explosives, all of which have become possible only through the growth of chemical knowledge. Ventilating systems as applied to theatres, halls and dwellings are based on chemical studies of the rates and causes of increase in the carbonic acid content in the air of rooms. The proportion of sulphur permissible by law in illuminating gas finds its justification in similar studies on the air in rooms in which such sulphur-bearing gas is burned.

The chemical and biological study of public water supplies, which received its first systematic development little more than twenty years ago at the hands of Drown and Mrs. Richards in the laboratories of the Massachusetts Institute of Technology, has been the means of saving countless lives throughout the world and has led to such understanding and made possible such control of sources of pollution as to almost justify the statement that for every case of typhoid fever some one should be hanged. Chemistry can now determine in advance of use the suitability of a given water supply for use in boilers or for the requirements of any special line of industry, as paper-making, dyeing, cloth finishing, brewing and so on. Furthermore it supplies the means for correcting undesirable characteristics in a water supply as by use of filtration apparatus, coagulants, water-softening systems and the Moore method for the destruction of the algae which in many waters are the cause of unpleasant tastes and odors.

Nowhere is the practical value of chemistry in its relation to the affairs of every-day life more strikingly demonstrated than in connection with our food supply. Chemical fertilizers are in large and constantly increasing measure responsible for the enormous total of our agricultural products. The whole fertilizer business is under the strictest chemical control, and the farmer buys his fertilizer on the basis of a knowledge of its composition and effective value which puts the average purchasing agent of a manufacturing company or public service corporation to shame. The Association of Official Agricultural Chemists, and the laboratories of the agricultural colleges and experiment stations throughout the country are doing more to keep down the cost of living than all the lawmakers we send to State capitols and Washington.

One of the most insistent of the demands of growing plants is that for nitrogen in form available for plant food. A small proportion of the necessary supply of nitrogen in the assimilative form is derived from the manure of farm animals and from animal wastes of various kinds, but for many years the world has depended upon the nitrate beds of Chili as the chief source of this indispensable element of plant growth. It is bad enough to be tied in this way to a single faraway deposit, but the situation becomes alarming when we discover that this deposit can hardly meet the world's demand for nitrate for another twenty years. One may contemplate the Malthusian theory with indifference or even with disbelief, but here is a condition not to be gainsaid. The world must do something to meet it within twenty years or the world must make up its mind to starve. Fortunately for the world the chemists are already doing something. They have recognized that 33,800 tons of nitrogen are pressing down upon every acre of land and have boldly attacked the problem of rendering available such portion of this inexhaustible supply as the world may need. The methods employed have been daring and brilliant in the extreme.

In 1785 Cavendish, in a paper before the Royal Society, describes the production of nitric acid by the passage of an electric spark through air. A hundred years later Bradley and Lovejoy at Niagara Falls, by drawing air through an apparatus by which 400,000 arcs were made and broken each minute, demonstrated the possibility of the commercial manufacture of nitrates from atmospheric air. Birkeland and Eyde in Norway pass the air through furnaces in which it comes in contact with enormous flaming and rotating arcs. Rossi in Italy brings the air in contact with highly incandescent material of special composition. Although by these several processes nitrate has been produced by thousands of tons it is doubtful if the artificial product can yet compete with Chili niter. Even now, however, the margin is not a wide one and the results already accomplished amply prove that when our agriculture begins to feel the pinch of a failing nitrate supply the chemist may safely be relied on to meet the situation. This assurance is rendered doubly sure by the fact that a solution of the problem along altogether different lines is already nearly or quite within our hands. Dr. Frank has shown that by heating calcium carbide, itself a comparatively recent product of the laboratory, in a stream of nitrogen there is formed a new compound, calcium cyanamide. The practical interest in this compound depends upon the fact that when exposed to a current of steam it decomposes into ammonia and carbonate of lime and that the same reaction takes place slowly in the soil when the cyanamide is mixed therewith. Since the nitrogen in ammonia is directly assimilable by plants and since calcium carbide requires for its production only lime and coke and power we may view without

* A public lecture to business men delivered June 29, 1911, under the auspices of the Indiana Section of the American Chemical Society.

serious concern the approaching failure of the Chilian nitrate beds.

But it is not only on the side of agriculture that chemistry touches our food supply. Chemistry pervades the packing industry, reducing the cost of food by utilization of by-products of the most varied character from oleomargarine to glycerine and soap and from soap to pepsin and adrenalin. To Atwater and his co-workers we owe our knowledge of the energy-producing value of different foods in the human economy and to Wiley and those other chemists behind him on the firing line we are indebted for the far-reaching benefits of the Pure Food Law.

Carbon disulphid made in the Taylor electric furnace has preserved the wine industry of France by destroying the phylloxera as it is ridding our own fields of prairie dogs and our elevators of rats and mice. Bread-making and brewing are coming each year more and more within the recognized domain of chemistry which is at the same time greatly enhancing the value of our staple crop by the increasing production of glucose, corn oil and gluten. Exactly one hundred years ago Kirchhof discovered the inversion of starch to glucose by dilute acids. To-day the United States alone is richer by $30,000,000 a year by reason of that discovery.

The relation of chemistry to the clothes we wear is perhaps less obvious but still of the first importance. More land is planted to cotton and cotton itself is cheaper because chemistry has taught the planter how to secure increased yields by proper fertilization and how to obtain increased profits by utilization of the cottonseed for oil and cattle feed. Chemistry is even now developing new sources of profit for the planter by adapting the short fiber adhering to the ginned cottonseed hull to the making of smokeless powder and the stalks of the cotton plant to paper-making.

The woolen industries are dependent upon chemistry for the processes of separating the pure fiber from the grease and dirt with which it is associated in the raw wool and for the methods of working up this wool waste into oleic acid, soap, lubricating oils and potash and ammonia salts, as well as for the process of carbonizing by which the wool is separated from the burrs and other vegetable material with which it is admixed in the fleece.

Many of the most brilliant achievements of chemistry have been directly concerned with the textile industries. A little touch of chemistry to cotton yarns and fabrics in the mercerizing process gave the world what is practically a new textile fiber—cotton with the beauty and luster of silk. A history of absorbing interest replete with struggle, the capture of positions of temporary advantage, the constant shifting of the fighting line, crushing defeats and signal victories might be written of the development of the bleach and alkali industry, upon the products of which the textile manufacturer depends for the finishing of his goods. We see the pathetic figure of Le Blanc dying in the poorhouse after enriching the world which Napoleon was devastating. No less interesting in its human and scientific aspects is the long story of the coal-tar colors in which chemists take so large a measure of justifiable pride. An investment of $750,000,000 follows Perkin's discovery of mauve.

Less notable, but nevertheless an industrial achievement of the highest order is the very modern development of artificial silk which, though made from wood pulp, far surpasses in brilliance and beauty the finest product of China and Japan. Closely related, thereto, is the artificial horsehair of which so large a proportion of women's hats are made and the still more recent artificial bristles of cellulose acetate with which you may have brushed your hair this morning.

A complex series of chemical reactions has its origin in the striking of every match, and civilization, as we know it, could hardly exist without the modern facilities for securing artificial light. For the extraordinary extension of these facilities during the past century the chemist has mainly been responsible. The immortal Faraday selected "The Chemistry of a Candle" as the subject matter of a classical series of lectures to audiences of children. From the rush candle and the tallow dip to the candles of stearin and paraffin is in itself a long journey, the milestones on which were set by Scheele, Chevreul, Heintz and Tilghman.

The refining of petroleum involved the solution of many difficult chemical problems. The Chicago fire is said to have been started by Mrs. O'Leary's cow which kicked over a kerosene lamp. In those days, however, it was not necessary to invoke the cow to start a conflagration with kerosene. Much of the lighting oil upon the market at that time would flash below 100 deg. F. We owe our present safety in the use of kerosene largely to the work of Prof. Chandler.

The production of illuminating gas is wholly a chemical process. When coal gas was first employed for lighting the Houses of Parliament the members might be seen gingerly touching the pipes to discover if they were not indeed hot from carrying such flame. That gas is now so cheap is due in large part to the development by Lowe of the chemical process for making water gas by passing steam through a bed of glowing coals and to the chemical processes for gas enrichment. By the Blaugas system illuminating gas is now produced in liquid form and distributed in steel bottles to isolated consumers like so much kerosene.

The gas mantle by which the illuminating power of gas is raised from 16 to 60 candles on a consumption of 3½ feet an hour constitutes one of the most signal triumphs of chemical research. Certain sands found in Brazil and known as monazite sands had long been a happy hunting ground for chemists by reason of the number of rare metallic elements to be found therein. They seemed to be a sort of chemical garret where everything not otherwise used up during the process of creation had been stowed. Dr. Carl von Welsbach was investigating the rare elements in these sands some thirty years ago and studying their spectra. It occurred to him that a better flame for his purpose or rather a better distribution of the metallic vapor in the ordinary Bunsen flame might be secured by distributing the metallic compound through the substance of a bit of cambric. He dipped the cambric in a solution of the salts, suspended it in the flame, burned off the cotton, and found that the fragile ash glowed with an amazing brilliance. So came into being the gas mantle which has revolutionized and saved the illuminating gas industry, though not until the initial discovery had been followed by years of the most painstaking and refined research.

In the development of electric lighting the chemist has played a part scarcely less important than that of the electrician.

The arc light was first shown by Davy between charcoal points and was maintained by the current developed by the action of chemicals in the enormous battery of the Royal Institution. To Faraday, whose achievements in electricity have overshadowed his renown as a chemist, we owe the discoveries upon which our modern methods of generating electricity are based. The early history of the incandescent lamp is a chronicle in equal measure of the difficulties of finding a proper material for the filament and those of producing the requisite degree of vacuum in the bulb. Both problems were solved by chemistry which first supplied the carbon filament made by dissolving cellulose, squirting the solution into a thread of the required diameter, drying and carbonizing the thread and thereafter flashing in an atmosphere of hydrocarbon vapor to deposit carbon on the filament precisely where and in exactly what proportion its original inequalities of resistance to the current made necessary. More recently Whitney and other chemists working in the same field first greatly raised the efficiency of the filament by the process of metallizing, so-called, and have since given us lamps of an altogether new order of usefulness by employing new materials, as tungsten, for the filament.

The second great problem, that of securing rapidly and cheaply the necessary high vacuum in the bulb, was solved in the most elegant manner by the extraordinary Malignani process. Malignani placed within the tubulature leading from the bulb and connecting the bulb and pump, a minute quantity of red phosphorus, started the pump and roughly exhausted to about 2 millimeters of mercury. He then sent through the filament a current so heavy as to bring the filament to intensive incandescence and cause the gaseous residue within the bulb to faintly glow so that the bulb was filled with a luminous blue haze. He then sealed off the pump by fusion of the walls of the tubulature below the phosphorus and with the bulb still glowing touched the tip of the blowpipe flame to that portion of the tubulature wall against which the phosphorus rested. With the vaporization of the phosphorus the blue haze instantaneously disappeared and an almost perfect vacuum was secured within the bulb. The process is not one of oxygen combustion as might on first thought appear and its ultimate mechanism was not understood until many years subsequent to its discovery.

The improvements in incandescent lamps in the last ten years have resulted in the saving of $24,000,000 a year in the cost of lighting as compared with the cost of equal illumination by the older types of lamp.

To the art of illumination Wohler and Willson have contributed the calcium carbide and acetylene found on every automobile and in a hundred thousand isolated homes; Pintsch and Blau have developed separate systems permitting the transport of illuminating gases in steel tanks for the lighting of trains and houses; to Hewitt we owe the mercury lamp, to other inventors the flaming arc, to Nernst the high efficiency lamp which has his name, and, long before them all, to Bunsen the blue flame burner utilized by Welsbach and which constitutes the basic element in every gas stove.

I have endeavored in this cursory and most inadequate survey to indicate something of the extent to which chemistry contributes to the satisfaction of the demands and needs of every-day life. The earning power of the science becomes more directly apparent in its relation to general industry.

American manufacturing is in many respects the most intensive in the world. Nowhere is plant scrapped so quickly to be replaced by larger, faster and more efficient machines. Nowhere else is labor so speeded up by piece work, bonuses, motion studies, gang organization and the other devices of the efficiency engineer. In no country can new office systems, typewriters, adding machines, time recorders, memory ticklers, duplicating devices and all the paraphernalia of the follow-up be sold as quickly and in none are they utilized so thoroughly. Our manufacturers understand these things, and what they understand they want, and are quick to make the most of, provided always they can use it in their business. They do not understand chemistry, naturally they do not propose to have any chemist teach them their business. This is reflected in the attitude of their subordinates which is commonly one of militant skepticism. They, like their masters, cut themselves off from that great co-ordinated and organized body of knowledge brought together by thousands of highly trained minds through the incessant questioning of nature during a hundred years. They pay less regard to many of the laws of nature than they do to city ordinances. When under these circumstances they fail to make a satisfactory profit in competition with more enlightened Germany, they jack up the tariff. They ignore applied chemistry which offers them better protection than the highest schedules of the Aldrich bill.

Let us consider a few concrete examples of the earning power of chemistry. A large pulp mill found itself with over 100,000 cords of peeled wood piled in its yard and this wood was beginning to rot. A few thousand gallons of sulphite liquor sprayed over the pile from a garden hose killed the fungus and saved the pile. The same mill was losing 23 per cent of its wood as barker waste. Laboratory trials proved that an excellent quality of paper could be made from this waste, all of which in this mill is now profitably worked up. Other mills still throw 20 per cent or more of their initial raw material away. The mill was cooking in 16 hours. Laboratory cooks were made in 7½ hours and the time of the mill cook reduced to 10. Finally, by a proper spacing of the digesters, the production of the plant was brought from 97 tons a day to 149 tons.

Cylinder oils generally cost about what you are accustomed to pay. Plants which employ a chemist pay from 19 to 27 cents. Manufacturers who do not need a chemist commonly pay 45 cents, 65 cents or even, if they know their own business very well, $1.50 a gallon. There is probably not a large plant in the country in which, if it is not already under chemical control, the lubrication account cannot be cut in two. In the engine room of one large cement plant the average monthly cost for lubricants had been $337. It is now $30. A concern paying 37 cents a pound for a special grease which the superintendent needed to run the mill now buys on specification for 5½ and the mill still runs. Another company within our knowledge saves $12,000 a year on cutting oils alone.

In a plant near Boston using two tons a week of special steel rolled very thin, their chemist was able in about two years to reduce the cost of the material from 80 to 40 cents a pound, while at the same time, standardizing and greatly improving the quality of the steel. We recall savings of $2,100 a year on wrapping paper, $3,600 on boiler compounds, $6,800 on a minor article of supply, $100,000 a year on a single raw material. Prof. Duncan in his fascinating and suggestive book, "The Chemistry of Commerce," says: "On three separate occasions the writer has visited the same glass house to see the workmen bailing out a lake of violet spoiled glass from the same immense tank, and all because it was deemed by the foreman 'theoretical' to have the manganese analyzed in order that its quality might be adjusted to its oxidizing value. Thousands of dollars were thus wasted and thousands more lost through failure of the firm to fulfil its contracts on time, and all of it could have been saved at the cost of, say, $10 for a simple analysis."

Chemistry points out the only proper way to buy supplies which is on the basis of their industrial efficiency by means of specifications defining the quality desired and rigid tests to make sure that quality is secured. Independent estimates by those in exceptional positions to know place the efficiency value of supplies as purchased and used by American manufacturers at 60 per cent of what it should be.

Comparatively few American manufacturers light their cigars with $20 bills. It is too slow a method of burning money. They prefer to burn it by shovelfuls, so they burn it in the boiler room. They forget that in ostensibly buying coal they are really buying heat and they pay good money for slate and sulphur balls with no knowledge of the actual number of British thermal units they are receiving for a dollar. Perhaps they depend upon a trade name ignoring the fact that coals from different mines in the same district vary greatly as does also coal from the same mine. Moreover, coal, like some other things, is not always true to name. A few years ago the Boston School Committee decided to buy its coal on specification. It had previously bought "New River coal of the best quality" and that definition of its desires was included in the specification which,

however, also included a chemical definition of what coal bearing this name should be. When deliveries were made by the same dealer who had previously supplied school coal they proved to be an inferior grade of Pennsylvania coal with sulphur in some samples running up to 6 per cent. When the contractor was called to account, he admitted that he did not know the State in which New River coal originates nor the transportation route by which only it could come to Boston. His comment to the committee was, "I don't see what you are fussing about, it's the same coal you've always had." Later, when the temperature in the piles in a certain school ran up 90 degrees in one day, he was called upon to remove all coal delivered by him to schools in that district and substitute therefor New River coal, which he did at heavy loss to himself and corresponding gain to the city.

Important as are the losses in the initial purchase of coal, they are small compared with those which attend its burning. Many a mill owner looks out of the window and sees, without knowing, his dividends go up the chimney. Under well regulated conditions of combustion the flue gases should contain not less than 12 per cent of carbonic acid gas. They frequently contain no more than 3 per cent. This means that for every ton of coal burned under the latter conditions more than 52 tons of excess air are heated to the high temperature of the flue gases. Chemistry meets these conditions by analyzing the flue gases and regulating the draft as indicated by the percentage of carbonic acid found. At $2.25 a ton, which is much below the average price, the fuel bill of the United States was over $1,000,000,000 in 1910. Of that amount, chemistry could easily have saved $100,000,000.

Chemistry aids the manufacturer who will listen to her teachings in countless other ways. It substitutes a rigid control of processes for the guesswork and uncertainty of the rule of thumb. It increases the productivity of labor by supplying more efficient processes.

In the sulphur mines of Sicily young boys called *carusi*, climb with groans and curses for four hundred feet bearing in a stifling atmosphere 40 pound loads of sulphur ore upon their backs. In Louisiana, thanks to Frash, two concentric pipes are driven to the ore, a hot solution of calcium chloride is forced through one pipe to melt the sulphur which is then pumped to the surface through the other, at a trivial fraction of the cost of raising the ore in Sicily.

In the old days of making paper the rags were piled in a heap, moistened and allowed to stand for weeks until fermentation had proceeded far enough to soften them. Now they are boiled with lime for a few hours. They used to be bleached by the slow action of the sun and dew as they were spread upon the grass. They are brought to better color now over night by bleaching-powder. Cutting tools made from high-speed steels multiply the output of the lathe and planer. The addition of 1 per cent of calcium chloride to the electrolyzing bath doubles the yield of potassium chlorate.

Chemistry aids the manufacturer by standardizing his product and reducing seconds and rejections. It costs just as much to tan goat skins into seconds as into firsts, though seconds bring a third as much. Chemistry even comes to the front bearing ammunition during an advertising campaign. You may remember the offer of a blowpipe and a bit of charcoal coupled with the information that if your paint was a lead paint, as the advertiser believed it should be, you could quickly prove its quality in the laboratory of your kitchen by reducing from the paint a little pellet of metallic lead. You do not see that advertisement now. It disappeared about the time that some one else informed the world that zinc paints are "unalterable, even under the blowpipe."

Nowhere, however, does chemistry render such efficient service to the manufacturer as in turning to profit waste and nuisance. To this phase of its service we shall return again.

To quote once more Prof. Duncan:

"During the next five years the small manufacturer who is swept out of existence will often wonder why. He will ascribe it to the economy of large scale operations, or business intrigues or what not, never knowing that his disaster was due to the application of pure science that the trust organizations and large manufacturers are already beginning to appreciate."

A few of us have been surprised, and none more than the railway managers themselves, by the well supported statement before the Interstate Commerce Commission that the railroads of the country could save $300,000,000 a year by the application of scientific management to the operation of their properties. Every chemist who has studied the problem is well aware that the entire amount in question could be saved through utilization of the proved results of chemistry alone.

Abraham S. Hewitt is authority for the statement that the Bessemer process has added $2,000,000,000 yearly to the world's wealth. By far the greatest portion of this increment has come through the economies which this process of steel-making has rendered possible in transportation.

Our own study of car painting practice on 21 electric roads has developed the fact that 50 per cent of the cost of materials and labor is wasted and more than 50 per cent of the time spent by the cars in the shops is unnecessary.

The classic work of Dr. Dudley as the head of the laboratories of the Pennsylvania system has gone far to standardize railroad practice throughout the country. Few, even among railroad men, realize how greatly the whole community is in his debt. His specifications cover rails, soaps, disinfectants, oils for signals and for lubricating, paints, steel in special forms for every use, car wheels, cement, signal cord and every detail of equipment. He has made the transportation of life and property cheaper, safer and more expeditious by reason of his application of chemistry to the problems of railroad management.

In a recent address Dr. Frankforter, voicing the opinion of every thoughtful chemist, said: "The United States is the most wasteful nation in the world; wasteful in living, wasteful in manufacturing, and wasteful in conserving its natural resources." So heedless and appalling is this waste that the mind trained in chemistry stands aghast. I have lately visited a southern lumber mill which burns 1,900 cords of wood a day in its incinerator. There are two hundred such burners in the country, limited in destructiveness only by the amount of material sent to them. From such wood chemistry is prepared to extract three gallons of turpentine a cord, 10 gallons of ethyl alcohol, or paper pulp to the value of $20. We waste each year 500,000,000 tons of coal and each day a billion feet of natural gas. With peat deposits fringing our entire eastern coast, we pay $4 a ton for coal delivered to the bog. Beehive coke ovens flame for miles in Pennsylvania and excite no comment, while the burning of a $1,000 house would draw a mob. We fill the Merrimac River with wool grease, making it a stench, while the towns along its course buy soap and fertilizer and lubricants from Chicago, Chili and Pennsylvania. We burn coal-tar in Massachusetts and import coal-tar colors at high prices from Germany. Over the great northwest we burn each year 5,000,000 tons of flax straw while we pay $40 a ton for imported paper stock from Norway. In the South 300,000 tons of paper fiber of the highest grade are burned with the cottonseed hulls to which it is attached or used with them to adulterate cattle feed. Corn-stalks to an incalculable tonnage rot or are burned each year while chemistry stands ready to convert them into feed containing 30 per cent of sugars on the dry basis, or into alcohol for light and power. Waste molasses is sold for three cents a gallon or dumped into the stream while alcohol sells for 40 cents a gallon. Skim milk is fed to hogs or thrown away because no one has the enterprise to extract its casein which is worth more than beefsteak for food.

In the face of such conditions we still meet young men who would inform us that the day of opportunity is past. The truth is that opportunity is knocking not once, but insistently and long at every entrance to the chemist's laboratory.

Nowhere is the earning power of chemistry better shown than in its ability to transform cheap raw materials into products of exceptional value. A cord of wood is worth perhaps $10 with a dry weight of a little over a ton. Its value, therefore, is about a half a cent a pound. In the form of chemical fiber for paper-making half the weight is lost but the remainder is worth 2¼ cents a pound. As paper it finds a market at 4 cents. Made into artificial silk by more refined chemical processes it commands $2.00 a pound, while as cellulose acetate bristles it is worth $4.00.

Many of our great industries are founded on minute chemical facts. Goodyear drops a bit of gum mixed with sulphur on a hot stove and the rubber industry results. The fact that silver salts happen to blacken when exposed to light is responsible for a corporation with $35,000,000 capital on which the earnings are over 20 per cent a year. The dipping of cotton yarn in caustic soda while tightly stretched has revolutionized the manufacture of the better grades of cotton textiles. Because the chemist learns that glycerine treated with nitric acid becomes explosive our army engineers are able to separate two continents. Becquerel, having placed a bit of uranium upon a photographic plate in a black paper wrapper, finds on development that the plate has blurred. The observation leads Prof. and Madame Curie to study similar actions by uranium ores and presently the thought of the world is enriched by altogether new conceptions of the constitution of matter, and our minds are awed by the magnitude of forces previously unrecognized.

Two classes of securities find a ready sale in Massachusetts—3½ per cent bonds and gold bricks. It is not an easy matter to raise money for a sound chemical proposition which promises 20 per cent. Much the same conditions undoubtedly prevail throughout the country. Boston, which invested largely in sea-water gold, the Hickman machine for converting starch to cane sugar, and the electrical process by which spruce wood was transformed into Australian wool with the grease in and the burrs attached, is just now figuring its losses on synthetic rubber. It left to other communities the formula of the Altoona cobbler for burning ashes, the process for converting water into kerosene, and the Lamoine diamonds. Men who turn a box of strawberries upside down and require a pastor's certificate of character from the office boy, rush into misapplied chemistry with never a thought of expert investigation or advice. The pity is the greater when one realizes, as every chemist does, the generous scale by which are measured the rewards of chemistry properly applied and wisely administered. Ten years ago a Massachusetts company with a capital of $20,000 was organized to conduct a manufacture based on chemistry; two years ago it charged off $700,000 on real estate and equipment; to-day it has a surplus of over $1,000,000. The great Badische Anilin und Soda Fabrik, the Elberfeld Co., Brunner, Mond & Co., the E. I. duPont de Nemours Powder Co., Meister, Lucius & Bruning, the Solvay Process Co., and many others well known to every chemist are among the most profitable industrial organizations in the world. The one thing lacking for an enormous development in this country of equally profitable enterprises based on chemistry is a reasonable appreciation by our business men of the earning power of chemistry.

The ordinary investor who may safely trust his own judgment in matters involving cotton, wheat, mortgages, railroad shares or telephones is not equipped by training or experience to decide upon the validity of propositions involving chemistry. He must, if he would avoid disaster, rely upon the opinion of disinterested experts. Such opinion should cover the soundness of the chemistry involved, the state of the art relating to the manufacture, the patent situation, the available market, the nature and extent of competition, the supply of raw material, the stage of development of the process, the cost of plant and the costs of production. These last should be itemized and the basis for conclusions regarding every item should be fully stated. Large allowances should invariably be made for depreciation and in most cases equally liberal allowances for contingencies. Secret processes should be left to the fool and his money.

In this environment and on this occasion I cannot forbear making a brief concluding reference to that organization of chemists which now enjoys your hospitality. At Northumberland, Pa., there lies the body of an obscure English dissenting clergyman who went through life on a salary of £30 a year, although he had enriched the world by the discovery of oxygen. It was around the grave of Priestley on July 31st, 1874, that the idea of the American Chemical Society first took form in the minds, and may I add the hearts, of a few American chemists, met to do honor to his memory. Subsequent meetings were held in New York at the home of that Nestor among American chemists, Prof. Charles F. Chandler, until on April 20th, 1876, the Society was formally organized. From a feeble organization of distinctly local character, with only 200 members in 1887, it has through the service and self-sacrifice of a long series of devoted officers become the largest chemical society in the world, with 5,500 members, and is to-day the most powerful influence in America for the advancement of chemical science. Its claim upon the loyalty and support of every American chemist can no longer be denied or set aside. With equal justification it may appeal to the whole community for recognition and encouragement.

There are in the country at least 100,000 doctors and nearly 125,000 lawyers. There are only 10,000 chemists to carry on a work incomparably more important than litigation and no less beneficial than medicine to the life of the community if that life is to be worth living. Some measure of the mere material benefits which chemistry can offer may be found in the fact that the annual production of the chemical industries of the United States is already nearly equal in value to our agricultural products. Let us, however, not forget that these benefits have come, as many more will follow, because chemists have never faltered in pursuing truth for years through the labyrinth of difficult researches with no better guide than the slender and often broken thread of an hypothesis. Turgot has said: "What I admire in Christopher Columbus is not that he discovered the new world but that he went to look for it on the faith of an idea."

The Rate of Growth of the Human Hand

SOME measurements of the rate of growth of children's hands is quoted in *Prometheus* from the Archiv für Anthropologie. The average figures obtained were 4.88 inches for boys at the age of seven, 6.46 inches in the fifteenth year and 7.16 in their twentieth year. In the case of girls measurements were available only from the seventh to the fifteenth year, during which the length of the hand increased from 4.76 to 6.34 inches. The most rapid growth was shown in boys during their seventeenth year, where the increase observed was 0.39 inches. Rapid growth also occurred during the thirteenth and fourteenth years, 0.31 inches each. Among school girls the time of most rapid growth lay in the thirteenth and ninth years, with an increase of 0.31 and 0.28 inches, respectively.

Large Sheet Steel Mill.

Siemens-Martin Furnaces—Tap Hole Side.

Three Thousand Ton Mandrel Forging Press.

Assembling ... Marine E...

The Creusot Iron...

A Visit to the Greatest Fren...

By Our Paris Correspo...

At Creusot, in the central part of France, are located the largest metallurgical works of the republic, surpassed in size by few European institutions of their kind, they are also among the oldest of these in France, their foundation dating back beyond 1840. The works are most completely equipped, and turn out the most varied products, from small bar and light sheet iron to the heaviest shafting for vessels, armor plate, heavy ordnance, and even an entire battleship—for the company has its own docks at Bordeaux. The Schneider Company, which operates the central plant at Creusot, also owns large artillery works at Havre, where cannons and torpedoes are built, and a special torpedo testing station near Toulon on the Mediterranean. Submarines and various structural iron work is also built at Chalons in another factory owned by the same company.

To give the reader some numerical conception of the size of the Creusot works it may be mentioned that the number of workmen employed is 20,000, and the area covered about 9,000 acres, including the artillery firing grounds. There are nearly 200 miles of railroad tracks laid through the grounds and establishing connection with the main lines, or with the coal and iron mines owned by the company. The total yearly output of iron and manufactured pieces is nearly 200,000 tons.

The Creusot works produce their own raw material in the shape of iron or steel of various grades, and a large section of the plant is occupied by blast furnaces and coke ovens. In this department we first come to an extensive set of seventy-three coke ovens of the Coppée type, laid out on economical principles so as to utilize the by-products and the waste heat. The furnaces produce 140,000 tons of coke annually. Of special interest is the method of collecting the tar and ammonia products. The tar is deposited mostly in the piping; the remainder is collected in a set of condensers and Pelouze apparatus, so that about fifty pounds of tar per ton of coal is obtained. Ammonia is another valuable by-product. It is collected and transformed into sulphate of ammonia.

We then come to the ...t furnaces
are five, each producing ...0 to 130 to...
per 24 hours. Of the ...ent kinds of
in the blast furnaces ...te iron for
verter, other kinds for ...ddling, high
Siemens-Martin steel, f...ry iron and
gases coming from the ...ace are use...
in two blowing engines ... 700 horse-p...
to run an extensive ele... plant. Th...
finished, is to contain ...0 horse-pow...
using blast furnace gas ...rnishes cur...
ing motors throughout ... works. A
engine plant with six ...s of 350 ho...
gives the requisite power ... lighting.

The annual production of basic con...
about 80,000 tons. Cr...e steel is a...
produced in the works. ...erves for ma...
up to 12-inch caliber as ... as for tool...
to high grades. In the ...emens-Marti...
works now produce a ... grade of
almost as good as cruc...steel, but m...
It is used, for instance ... ingots rang...
sizes for artillery, or lo...tive and au...
up to the large 60 or 7...n ingots fo...
armor plate and heavy ...fting. Othe...
duced are soft steel for ...r plates and
or for machine work. ...re we find
groups of Siemens-Ma... furnaces
ingots up to 120 tons. ...ry striking
which the melted metal ...arried to t...
ton hydraulic press to ...urned out
to 75 tons and up to 5 ...diameter.
of steel figures for 100,0...ons annuall...

There is also an exte... foundry f...
ture of cast steel. Th...an now be
most difficult pieces, ...s rolling w...
also gun carriages and ...ike. For d...
five coke-heated ovens ...rolled by r...
meters are used. For ... larger piec...
terns or hydraulic mold... machines a...
steel foundry, pieces up to ...0 tons can r...

[illegible]mbling S[illegible]r Marine Engines.

[illegible]eusc[illegible] Iron Works

[illegible]he Gr[illegible]est French Foundry

[illegible]ur Pari[illegible] Correspondent

[illegible]me to the [illegible]t furnaces of which there
[illegible] produci[illegible]0 to 130 tons of pig iron
Of the [illegible]nt kinds of iron produced
[illegible]urnaces [illegible]te iron for the basic con-
[illegible] kinds for [illegible]ddling, higher grades for
[illegible]n steel, f[illegible]y iron and the like. The
[illegible] from the [illegible]ace are usefully employed
[illegible]g engines [illegible] 700 horse-power, and also
[illegible]ensive ele[illegible] plant. This latter, when
[illegible] contain [illegible]0 horse-power in engines
[illegible]rnace gas, [illegible]rnishes current for operat-
[illegible]roughout [illegible] works. A separate steam
[illegible]vith six [illegible]s of 350 horse-power each
[illegible]isite powe[illegible] lighting.
[illegible] productio[illegible]f basic converter steel is
[illegible]tons. Cr[illegible]e steel is also extensively
[illegible]e works [illegible]erves for marine projectiles
[illegible]aliber as [illegible] as for tool steel from low
[illegible]s. In the [illegible]emens-Martin furnaces the
[illegible]roduce a [illegible] grade of steel which is
[illegible]l as cruc[illegible]steel, but more economical.
[illegible] instance, [illegible] ingots ranging from small
[illegible]ery, or lo[illegible]tive and automobile pieces,
[illegible]e 60 or 7[illegible]n ingots for 12-inch guns.
[illegible]d heavy [illegible]ting. Other varieties pro-
[illegible]steel for b[illegible]r plates and dynamo sheets.
[illegible]e work. [illegible]ere we find the extensive
[illegible]emens-Mar[illegible] furnaces which produce
[illegible]20 tons. [illegible]ry striking is the way in
[illegible]ed metal [illegible]arried to the great 10,000-
[illegible]press to b[illegible]turned out in ingots of 16
[illegible]up to 5 [illegible] diameter. In all, this kind
[illegible] for 100,0[illegible]ons annually.
[illegible] an exte[illegible] foundry for the manufac-
[illegible]eel. Th[illegible]an now be made into the
[illegible]ieces, su[illegible]s rolling ways for turrets,
[illegible]ges and t[illegible]like. For drying the molds
[illegible]l ovens [illegible]rolled by registering pyro-
[illegible]d. For t[illegible] larger pieces, metalic pat-
[illegible]lic mold[illegible]machines are used. In the
[illegible]ieces up t[illegible]0 tons can now be produced.

After the casting and trimming, the pieces are annealed in coal-heated furnaces working up to 1,000 deg. Cent., and controlled by means of pyrometers.

The bar and plate iron department forms a large section of the works. Its size can be judged from the fact that about 2,700 men are employed here. The quantity of material turned out annually is about 150,000 tons of rolled products. A great variety of material is produced in the numerous rolling mills, and different qualities of steel are manufactured to suit all kinds of purposes. A large amount of steam power is needed to operate the rolling mills, so that a considerable number of engines are installed. For part of the engines the boilers are heated directly by the heat of the coke furnaces, while the remainder of the boilers use coal. We will give a brief account of the most noteworthy of the rolling mills which turn out different kinds of product. There are first of all the mills for bar and profile iron. The bars are rolled in eleven sets of rolls arranged one behind the other in line, and driven by Corliss engines. Next to the rolls are the furnaces for heating the iron. Good economy is here secured by installing a set of Schneider boilers in connection with the furnaces, so that part of the heat which would otherwise be wasted is now used to heat the boilers and produce steam for various engines. Part of the rolls are used exclusively for steel; these are provided with a heating furnace of the continuous type which replaces four or five ordinary furnaces and gives considerable economy per ton of the product. Others sets of rolls are used for blooms and heavy plate. The blooming roll serves to supply all the other mills of the plant, and is operated by a 3,000 horse-power reversible engine. At the same time the engine drives a plate rolling mill of 16 feet table width. Blooms are produced here at the rate of 350 to 400 tons an hour.

After the heavier products come the moderate sized and thin plate. The former is turned out by a mill having 12 feet table width and a second and larger one of 14 feet width, besides several others. One of

In the Armor Plate Shop.

Rolling Mills for Armor Plate.

Manganese Steel Pouring Room.

the most important products from this part of the works is thin sheet iron such as is needed for many industries. One of these is dynamo plate, of which alone there is a large output. The manufacture of thin iron plate has been carefully worked out at the Creusot establishment, and they now claim to turn out iron which rivals the best English or German products. In order to regulate the matter of demand and supply for this material, a large stock of 4,000 tons is always kept on hand so that rush orders can be filled at once.

An interesting part of the plant are the rolling mills for armor plate and the largest sizes of sheet steel. For this work a separate shop is fitted out, where the rolls are driven by 14,000 horse-power engines. These rolls with their tables are remarkable for their size, and produce armor plate of 13 feet width and 60 feet length, with a thickness ranging up to 10 inches. Plate of this kind is rolled from large steel ingots weighing 50 or 60 tons, and sometimes even as much as 75 tons. Another shop is devoted to the manufacture of tires for car wheels, especially for railroad use. In making these they start from an octagonal ingot, which is then cut up in flat sections. The ingots weigh as much as four and a half tons. A special testing laboratory is fitted up for checking up the products of the various mills from day to day, using samples cut from the bar or sheet. These tests include breaking or bending trials, and cold punching.

Another department of the Creusot works comprises the forging presses and hammers used in making armor plate and cannon of large caliber, also projectiles and other large forged pieces. First we come to the forging shops proper, and note the seven large hydraulic presses of 1,000 to 6,000 tons power and two steam hammers of 100 and 20 tons, respectively. Rolling cranes as well as various hydraulic or steam cranes, some of which weigh as much as 1,000 tons, are used in these shops, and we observe many furnaces for heating the ingots for the forge. Near by are the tempering and cementation shops, and the annealing of the iron is also carried out here. There is one large furnace for cannon of great length; this measures 60 feet in height and 6 feet in diameter. Beside it is a tempering tank 80 feet deep. There are also other furnaces for cannon, and a large horizontal furnace, over 60 feet long by 9 feet in width, for annealing heavy pieces after forging. A number of furnaces are used for the cementation process; they will accommodate plates of 25-foot length and 10-foot width. Three large tanks serve for oil or water tempering, and in another tank water spray tempering is carried out.

Connected with the forge works is a special machine shop fitted out with heavy machine tools for carrying out some of the rough work upon the large sized pieces. As an example, we may mention three heavy lathes for cutting up ingots; one of these has 55 feet working length. It can also do rough shaping of forged pieces weighing up to 100 tons. Another interesting piece is a hydraulic machine for boring out the round ingots after shaping in the hydraulic press. Such ingots are then sent to be forged on the mandrel. There is also a large boring machine of the vertical type which is used to bore out cylindrical turrets for battleships and the like, ranging up to 16 feet in diameter and 20 feet in height.

Not far from here are two shops for working up armor plate, with a great number of machine tools such as lathes and planers, also circular saws which cut plate of 25 feet length and any thickness. Next come the projectile machine shops, where we find nine hydraulic presses of 250 to 350 tons installed; also many furnaces for heating, tempering and annealing, as used in the manufacture of melinite and other shells.

While in the forging shops we had occasion to watch an interesting piece of work, namely, the forging of a tube for a 12-inch cannon from a round ingot. This was done in the 3,000-ton hydraulic press. The ingot came in the first place from the great 10,000-ton hydraulic forging press, where it had been pressed while in the liquid state. We also saw a forged piece of unusual size—a steam turbine drum for the steamer "France." This represents one of the finest specimens of difficult forging to be found in Europe. The piece is 10 feet in diameter and the same in length, and weighs 27 tons.

In the mechanical construction shops, where machine work of all kinds is carried out, over 2,700 men are employed. Among the products here turned out are locomotives, marine engines, turbines, gas and oil engines and the like. Connected with this section are the drafting rooms, which are laid out on a large scale. The files of drawings contain the original plans of all the apparatus made since the year 1855, or about 250,000 drawings. Another filing office has the older drawing dating as far back as 1839, that number about 70,000.

We can only briefly refer to the machine shops, which are divided into five main groups. One group is devoted to boiler work, either in iron or copper. Here are built locomotive and marine boilers, also engine boilers of various types. Plate iron work for battleship turrets is also carried out here. A foundry installed in these shops is specially fitted out for molding large pieces such as turbine drums or large gas engine cylinders. Near by are the hand forging shops which take steel ingots up to 10 tons. Among the tools are thirty steam hammers of all sizes up to 10 tons. Here are turned out locomotive parts, shafting for torpedo boats and destroyers, and parts of smaller cannon under 3-inch caliber. Then we come to the locomotive shops which form a separate group and which alone employ 570 men, turning out on the average seventy-five locomotives yearly.

Farther on are the machine and assembling shops for different types of engines such as marine engines, also city gas, producer- or blast furnace-gas engines, and steam engines of all kinds. Steam dynamo groups are erected here, and also large blast fans. We also noted many oil engines for vessels, steam turbines and Corliss engines.

Among other interesting operations which we saw in the course of our visit was the rolling of a 35-ton ingot into armor plate to be used on the battleship "Vergniaud." One of the great armor plates was also tempered in the oil bath, and we observed the water tempering of a tube for a 20-inch gun in the tank of 80-foot depth. There are naturally many other points about such an extensive establishment as the Creusot works which we are obliged to omit in our necessarily brief description. We are indebted to M. Petit, one of the chief engineers, for much of the information gleaned during our visit to the plant.

The Gas Power Field for 1911*

A Review of the Past Year

By Robert H. Fernald

The past year of the Gas Power Section has been one of continued prosperity. The progressive policies pursued by the Executive Committee and the various technical committees during the four short years since the birth of the Section have placed it definitely on a basis that assures its future. The reason for its being and the firm belief in a large future for the organization are readily understood by reviewing briefly the steady, healthy development of gas power during the past year—a year that places gas power for large units well beyond the uncertainties of the purely experimental period.

LARGE GAS ENGINE UNITS.

The development of large gas engine units has gone steadily forward for the past decade. The first engine of this class was that exhibited by the John Cockerel Company at the Paris Exposition in 1900. This was an engine of 600 horse-power rating. At the present time 1,500 horse-power in each cylinder of the four stroke cycle type and 2,000 horse-power in each cylinder of the two stroke cycle engine are reported for one of the exhibits at the recent exposition at Brussels. This means units of 8,000 horse-power of the twin tandem double-acting type. The present status of the large blast furnace gas power plants has been ably and thoroughly presented at recent meetings of this Section, and the papers and discussions form a valuable portion of the proceedings of the society.

It is understood that at least one company is prepared to install gas engine plants of large power capacity at a cost not exceeding and in some instances less than that of the corresponding steam turbine installations.

MARKED STRIDES IN THE DEVELOPMENT AND APPLICATION OF THE DIESEL ENGINE.

Although the steam turbine has superseded the reciprocating steam engine for electrical development in central station work, and will probably hold the field for some time to come, it is interesting to note that the Diesel engine, owing to its great success in small station service, is looked upon seriously as a possible rival to the steam turbine within a short time. In a paper recently presented before the Municipal Electric Association at Brighton, England, the relative cost of a 10,000 kilowatt installation for steam turbines, gas producers and engines, and Diesel engines, was discussed at length. The author's proposition was to use seven sets each of 1,450 kilowatt capacity. His figures of operating expense, etc., are decidedly in favor of the Diesel engine installation.

Attention was also called to the very economical use of these engines as a substitute for sub-station converting machinery. Such stations are already putting in their appearance in London.

In this connection it is interesting to note the development in point of size of the Diesel engine. Engines of a few hundred horse-power have become common in European practice. In Swiss electric stations Diesel engine units of 2,000 horse-power are now in use, and one writer on the subject states that the development of the large-sized Diesel engine has been so successful that it will not be long before 1,000 horse-power developed in one cylinder will be thought nothing extraordinary. One company of world-wide reputation is at present considering more than 2,000 horse-power in the single cylinder of Diesel engines. It is stated that engines of this type with four cylinders developing 1,000 horse-power each can be made as light as the corresponding triple expansion steam engine.

The weight of such engines compares favorably with that of the corresponding turbines and boilers. It is understood that a 1,000 horse-power installation of this type weighed only 187 pounds per horse-power as compared with 180 pounds for a steam turbine and boiler installation.

The crude oil engine is now definitely under consideration for all types of marine craft. For small vessels the advantage lies in the safety afforded by the use of crude oil as compared with the lighter oils. The crude oil engine is being used by many of the principal navies of the world for sub-marine boats and designs are already under way for comparatively large engines for torpedo boats and other similar craft.

A few months since, the "Vulcanus," a vessel of 1,900 tons displacement, 196 feet long, equipped with six-cylinder four-cycle single-acting reversible Diesel engines, was put in regular service between Holland and Borneo. This engine is about 500 brake horse-power capacity at 180 revolutions per minute. The fuel is a crude oil from Borneo and the quoted guarantees are 0.42 pound per brake horse-power hour at full speed; 0.44 pound at three-quarters speed; and 0.5 pound at half speed. In a recent trip the "Vulcanus" covered 3,312 miles in 19 days and 3 hours. The average speeds varied from 6.86 knots to 7.80. It is understood that the average consumption for this ship amounts to one ton of fuel oil per 100 knots.

The technical journals of recent date record many such installations. Among these Russia is credited with at least four freight vessels of 1,000 horse-power and two 14-knot gunboats of the same horse-power rating.

Tests are taken in view for two vessels nearly 400 feet long, of 7,000 tons capacity, fitted with Diesel engines of 2,500 horse-power rating, and with two auxiliary Diesel engines aggregating 500 horse-power, to be tried out in European waters.

A recent announcement is to the effect that the Hamburg-American Company proposes to build an ocean liner using Diesel oil engines for motive power.

An interesting comparison will shortly be placed before the public by the British Admiralty, as it is proposed to try out side by side in a twin-screw cruiser a steam engine and a Diesel engine of 6,000 horse-power rating.

Another destroyer recently ordered by the British Admiralty, according to current reports, will have on each shaft a steam turbine and a Diesel engine. The plan is to operate the turbines when high speeds are required, but under cruising conditions, when the speeds are low, owing to the poor economy of the steam turbines, the Diesel engines will be used. The combined economy due to this arrangement will be exceedingly interesting.

One of the interesting features of this engine is the fact that there seems to be a marked tendency toward the two-stroke cycle for marine work.

With the introduction of these engines the discomforts of the stoke hole will be greatly reduced and the amount of labor required will be less than under present marine conditions and the character of labor much improved.

Although it is not probable that steam installations are to be rapidly displaced in the larger ocean-going craft, yet the crude oil engine seems to be especially adapted for such service as that previously indicated. The fuel needed approximates a third of that needed for the steam engine, thus greatly increasing the radius of action if the same weight of

* Paper read before the Gas Power Section of the American Association of Mechanical Engineers.

fuel be carried. Boilers can be done away with and their space utilized for carrying cargo.

It is reported for a freight vessel of 2,700 tons that a saving of over $19 per day was made by using oil at approximately $11 per ton, instead of coal at about $2 per ton.

TAR AS A FUEL FOR DIESEL ENGINES.

Tar oil has become more or less common as a fuel in Diesel engines of 600 or 800 horse-power rating and it is understood that it is used in at least one engine of 4,000 horse-power rating. Recent experiments indicate that both thin gas retort tar and thick coke oven tar can be used in a similar manner by injecting into the cylinder a small percentage of light oil to assist in igniting the tar. It is claimed that a wide range of tars can be used in this manner without producing smoke or appreciable residue. In tests at the Körting works about 2 per cent of the ignition oil was used at full load and about 13 per cent at half load. Reports indicate that an order has been placed for a 600 horse-power Diesel engine to operate on raw tar.

INTERNAL-COMBUSTION ENGINE LOCOMOTIVES.

Locomotives using internal-combustion engines and operating on the standard gage track have recently been put into service. The range of fuel for these engines covers gasoline, benzol, alcohol, and petroleum.

The Prussian State Railways are reported to be operating a 1,000 horse-power locomotive using a Diesel engine as motive power.

GAS TURBINE.

Results are soon to be expected from the more recent investigations and tests relating to gas turbines. It is believed that some of the types are based on current principles and that after a rotary air compressor of satisfactory design has been secured, rapid progress in the development of this prime mover may be expected.

RECOGNIZED RELIABILITY OF INTERNAL-COMBUSTION ENGINES.

Not only do the renewed and increased orders for internal-combustion engines by the great manufacturing corporations indicate a feeling of assured reliability, but the subsidizing by European war departments of gasoline motor lorries indicates a feeling of reliance in the internal-combustion principle that is beyond dispute. These vehicles will be held subject to purchase in case of need by the War Department. An important stipulation is "the engines must be of the internal-combustion type using gasoline, and by preference having four cylinders."

THE HUMPHREY PUMP.

This internal combustion pump has been before the gas power public for two or three years past. Many similar internal-combustion pumps are clamoring for admission to the field. The comptroller in discussing the validity of the Humphrey patents, states "the Humphrey pumps show an important advance in the art. Although many applications have been filed for patents since 1858, none has embodied the principles of the Humphrey pump."

The 1,000 horse-power pump occupies about the same space as the tandem double-acting gas engine of the same power.

Mr. Humphrey says: "With the compression pressure of 11 atmospheres absolute the theoretical thermal efficiency of the cycle is 52.5 per cent, whereas that of the Otto cycle is only 40 per cent when all corrections for varying specific heats are allowed for. With very moderate compression, under 50 pounds, an actual thermal efficiency of 23 per cent has been obtained on a four-cycle Humphrey pump. This corresponds to 0.95 pound of anthracite per hydraulic horse-power hour, and was obtained on a lift of only 35 feet."

ILLUMINATING GAS FROM SEWERAGE.

A report is current to the effect that the municipality of Brunn, Austria, is to convert the solid residue from the town sewerage into illuminating gas. The figures reported indicate that one pound of solid residue is secured from 60 gallons of sewerage and that 380 cubic feet of gas are obtained from each 100 pounds of solid residue. The calorific value of the gas is reported as at least equal to and the light better than that of coal gas.

UTILIZATION OF THE WASTE HEAT OF THE GAS ENGINE.

Various methods of utilizing the waste heat of the gas engine exhaust have been attempted from time to time, and the demand for such devices for heating buildings has been considerable. Several schemes for accomplishing this result are now commercially in use, but according to recent opinions the most efficient method of utilizing the exhaust is through a combination of gas and steam engines.

Present practice indicates that about three pounds of steam are generated per brake horse-power hour by means of exhaust boilers.

According to Mr. Chorlton the use of exhaust boilers with efficient steam engines and specially designed gas engines of the two-cycle type will effect marked thermal economies and reduce initial cost of the installation per horse-power.

One of the technical journals states that Mr. Chorlton shows by numerical examples the possibilities of such an engine, first examining the case of the addition of a steam end to a normal economical gas engine. He assumes a standard engine to use 9,500 British thermal units per brake horse-power hour. As the engine is ordinarily arranged with jacket feed to the boilers, we may take 40 per cent of this amount to be recoverable. From this, at 80 per cent efficiency of conversion at 100 pounds pressure, we would recover about 2½ pounds of steam per brake horse-power hour. This amount in an ordinary simple steam engine would not give more than 10 to 12 per cent of the main engine power, a return which hardly justifies the first cost of the steam cylinder. Consequently no development has taken place in this direction.

When, however, we are dealing with a special combined compound engine, each part of which is made in the most suitable way for the purpose required, we get a very different result. In order to reduce the cost of the gas engine part, the compression would be lowered, and with the ignition retarded a much lower maximum pressure and temperature would result; the total heat units used would go up to, say, 12,000 British thermal units, but more would be rejected to the exhaust, and with a special arrangement of boiler, economizer pipes, superheaters in exhaust, etc., 50 per cent waste heat should be recoverable. There should be obtained from this 4 pounds of steam per brake horse-power hour.

The steam cylinder used would be similar in type to that of the two-cycle engine—that is, with no exhaust valves. The unidirectional-flow engine of this type has been largely reintroduced in Germany with very economical results. The jacketing of the ends could be done by exhaust gas. For small engines of this type it is safe to assume a steam consumption of 12 pounds per brake horse-power hour; a consumption of 10 pounds has been obtained in actual practice. Hence the power obtained from the steam cylinder would be one-third of that of the gas cylinder, and the consumption for total effective power would be reduced to 9,000 British thermal units per brake horse-power hour, less than for the economical gas engine alone.

SURFACE COMBUSTION.

By what he terms "surface combustion," Prof. Bone reports for gas-fired boilers evaporations of 21.6 pounds per square foot of heating surface and an efficiency of heat transmission of 94 per cent. The heat balance of a test reported by him shows:

Gas burned per hour (at 32 F. and 14.7 lbs.)	997 cu. ft.
Net calorific value of gas....................	562 B. t. u.
Total heat supply to boiler per hour......	559,800 B. t. u.
Temperature of feed-water................	42 R.
Pressure of steam.........................	100 lbs
Water evaporated per hour................	450.3 lbs.
Water evaporated from and at 212 deg. Fahr.	550 lbs.
Heat transmitted to water 450.3 × 1172 equaling	527,800 B. t. u.
Heat ratio 527,800 ÷ 559,800.............	943

In the reports of the surprising results of these investigations, attention is called to the fact that the combustion was perfect as was shown by analysis. An efficiency of 94 per cent was obtained. Deducting 4 per cent for the power required for supplying air pressure still leaves 90 per cent.

Prof. Bone says: "The new boilers could be set up in brick work and require no elaborate flues or chimneys. They are liable to no strains, as they are short. With some sacrifice of efficiency the evaporation could be raised to 30 pounds per square foot. The steam was raised quickly (steam at 100 pounds pressure obtained in 20 minutes from cold start) and tubes could be grouped and cut out separately so as to vary the fuel consumption to suit the fluctuations of load."

Sixty-five per cent of the steam was generated in the first foot of the tubes; 25 per cent in the second foot; 10 per cent in the third.

PRODUCER-GAS FROM LOW GRADE FUELS.

Progress is steadily being made in the utilization of lignite, heat, and high ash coals in producer-gas work. The investigations of the Canadian government show that peat can be prepared for fuel purposes at a cost averaging from 30 per cent to 40 per cent of that of an equivalent British thermal unit value in anthracite in Canada.

As the foundation of a method that may result in extensive use of high ash fuels without prohibitive cost of operation, attention is directed to the present producer-gas investigations of the United States Bureau of Mines, resulting in the successful fusing of the ash and the use of water-cooled producer-linings.

In line with this specific conservation of fuel resources it is interesting to note that one estimate states that the United States Steel Corporation alone, through its installations of blast furnace gas engines, displaces, or saves, a consumption of approximately a million tons of coal per annum as against the old-fashioned methods.

SMALL PRODUCERS FOR BITUMINOUS COAL.

Reports are persistently before us indicating the successful development of gas producers of small power to operate on bituminous coal, coke breeze, anthracite screenings, "front and cinders," etc.

Such plants are in great demand, but it is doubtful whether the development and application have been as great as the advertising these plants receive. It is interesting to record, however, that a company, manufacturing anthracite gas producers and gas engines, that expressed in 1904 its firm conviction that the government tests with bituminous coal in producers would fail utterly, recently put itself on record as recommending the use of its own engines with small bituminous producers manufactured by another company.

CRUDE OIL GAS PRODUCERS.

The development of the crude oil gas producer, for which there is great demand in oil regions remote from the coal field, has been exceedingly slow, but it is believed that very definite progress has recently been made along this line. The most recent notes on this subject relate to the Grine oil producer. In this type steam spray is used for atomizing the oil which is introduced into the upper part of the generator, where partial combustion takes place. The down-draft principle is then applied and the hydrocarbon broken up and the tar fixed by passing through a bed of incandescent coke. Mr. Grine reports that a power plant using one of these producers has been in operation a year in California. With crude oil as fuel, costing 95 cents per barrel, or 2.3 cents per gallon, the plant is reported to develop the same amount of power per gallon of crude oil as is ordinarily developed by the standard internal combustion engine operating on distillate at 7 cents per gallon. Including the cost of fuel, labor, supplies, interest, depreciation, and taxes, Mr. Grine states the cost per brake horse-power hour to be 0.76 cent for a plant of 100 horse-power rating.

FUTURE INVESTIGATIONS.

The opportunity for investigation in the gas power field is at present unlimited, as is evidenced by the fact that nearly a hundred important gas power problems are at present on file at the United States Bureau of Mines under the head of "Proposed Investigations."

CONCLUSION.

It is gratifying to note that each year eliminates many of the absurd prophecies regarding the elimination of practically all prime movers save the internal combustion engine and that the past year may be regarded as one of steady, conservative progress and development in the field that is of such keen interest to so large a percentage of the total membership of the American Society of Mechanical Engineers.

Sanitation of Swimming Pools*

THE work of protecting and purifying public water supplies has suggested the investigation of the condition of a related subject—the water of swimming pools. Within a few years the possibility has been realized of such pools becoming a means for the transmission of disease. It is believed that nose and throat affections may be, and often are, transmitted by the water of the swimming pool. The danger of the transmission of intestinal diseases is less only because such diseases are more rigorously controlled and isolated. At least one record is at hand of an epidemic of typhoid fever which was spread by a swimming pool.

Conclusive data are at hand to show that, in spite of the utmost care in enforcing sanitary and hygienic regulations upon users of a pool, each person adds his quota of bacterial contamination to the water. As the organic matter which enters the water is kept at a relatively high temperature, it offers a good culture medium. It has been found that a temperature of 75 deg. Fahr. greatly favors bacterial growth under these conditions over that of 70 degrees.

Consecutive chemical analyses made at various colleges in the United States have shown that the organic contamination increases progressively from day to day while a pool is in use. Bacteriological analyses show a progressive increase up to the point where the Malthusian Law asserts itself to bring about a balance.

Experiments have shown that disinfection will take care of the bacterial contamination of swimming pools. Ordinary bleaching powder, or calcium hypochlorite, now so widely used in water supplies, has been selected by all as the most efficient substance for this purpose.

Results achieved point to the efficiency of chloride of lime as a disinfectant, when applied in quantities that will furnish from 0.4 to 1.0 part per million of available chlorine at intervals of one to three days.

This conclusion has been made more certain in the light of confirmatory evidence from various institutions, where accurate and careful observations have been made of conditions governing the use of pools.

*Abstract of paper read before American Society of Municipal Improvements by Melvin C. Whipple and John W. M. Bunker published in the *Municipal Journal*.

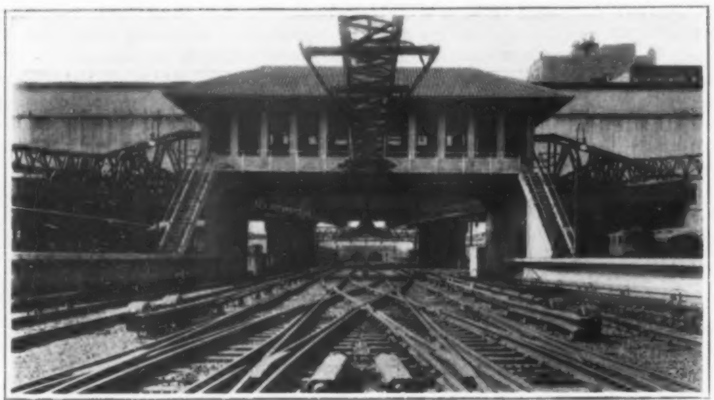


Fig. 1.—Exterior View of the Signal Cabin "A."

Fig. 2.—The Interlocking Machine of the Signal Cabin.

Signal System at Pennsylvania Station, New York

One of the most complete and unique electro-pneumatic signal systems in the world is that of the tower "A" terminal area, in the new Pennsylvania Station in New York city. The accompanying illustration, Fig. 1, shows the exterior of the cabin, while Fig. 2 shows the interlocking machine of this cabin, and Fig. 3 the electric equipment in the basement. Fig. 4 is a view of the tracks and signal equipment looking west from cabin "A."

At the New York tunnel extension of the Pennsylvania Railroad the switch and signal was made unusually complete. It has been pointed out that the physical conditions surrounding the station yard are exceptional, as the yard is practically underground, and the view is obscured by numerous yard structures and building columns, while the clearances, both overhead and between the trains and structures are very limited.

The space available for the installation of signal and apparatus was restricted, and the character and extent of the train movements required the realization of the fullest capacity of all track facilities, necessitating the greatest freedom for simultaneous parallel movements, while the complexity of the track plans and the presence of yard service facilities, such as the piping system for steam, air and water, drainage and traction conductors and conduits, required that the signal appliances should be mounted on special foundations and that control wiring should be run in permanent and accessible shape in a conduit system.

On account of these conditions it was found necessary to divide the control of the yard movements between four different power-operated switching cabins. These cabins each controlling only a part of the yard, required a certain amount of inter-connection to insure rapid and complete movements in the yard, a result accomplished partly by electric locking between cabins, partly by light indicators on the track models in the cabins to show how the tracks between them are occupied and when trains are approaching, and partly by central communication by telephone, etc., with the train director. At the Manhattan Transfer, where the change is made from steam to electric power, two very complete electro-pneumatic interlocking plants are provided, and at the Sunnyside yard four plants are required.

The tunnels involve train movements over heavy grades at high speed, and at the minimum safe interval, a condition which led to the adoption of automatic block signaling with overlaps of the same length as the block sections; in other words, a two-indication block in which a "proceed" indication requires that two sections shall be unoccupied. "Caution" indication must show that at least as much track is unoccupied as the foregoing. The length of the sections is variable, depending on the grade and maximum train speed at the point in question, being made 150 per cent of the length in which a stop can be made by the application of the brakes.

There is a "track stop" installed at each block in the tunnels to apply the train brakes automatically should a danger signal be overrun. The closest headway at which trains can be run at normal speed, therefore, is the time required to pass over two block sections corresponding to about two minutes, and at restricted speed under caution signals, one block, or about one and one-half minutes. "Lock and block" control has been provided between the station and the Long Island approach of the East River tunnels, so that if necessary any one of the four tunnel tracks can be operated in the reverse direction.

The North River tunnels have the same provision, with the addition of automatic signals for following movements. The grades are such that the spacing of signals for reverse movements could not be the same as for movements in the normal direction of traffic, and on account of this there was considerable complication in putting the signals for a certain direction out of commission and those for the opposite direction in, and changing the control of the automatic stops so as to make them effective at the right time.

The meadow section has been equipped with automatic semaphore block signals without track stops. Complete reverse movement signaling has been provided for at each block. At the Hackensack River, midway of the section, the drawbridge has been provided with the usual interlocking bridge and signal appliance and cross-overs between tracks at the east approach to the bridge so that reverse movements may originate either east or west from this point. Signal indications are given in three positions in the upper right-hand quadrant, automatic blades being pointed for day indications and marked by a staggered light for night indications. Interlocking signals are multiple-arm, using square-ended blades with vertical marker lights. In the station one-speed signaling is used with calling-on arms where required.

On account of the absence of daylight conditions in the tunnels and in the covered portion of the terminal area, the indications are given entirely by light. The light signal contains no mechanism other than that required for changing the colors of stationary lights in such a manner as to reproduce the same colors and combinations as called for by changes in the position of a semaphore signal under like conditions in the controlling currents. The signals are cast-iron receptacles carrying colored lenses, behind which are located incandescent lamps (two in multiple for each lens) and the mechanism consists of relays housed in a separate shelter near the signals, the contacts of which are adapted to shift the current from lamp to lamp and thus change the colors displayed as the relays are energized or de-energized by manipulation of the machine levers, or by the action of track circuits.

On account of the difficulty of obtaining ample clearances and suitable supports for semaphore signals in the yard, and in order to maintain a uniform type of signal within the station area, special hooded lenses and lamps of high candle-power are used in the "lamp" type of signal in these exposed places, and are found to give effective indications for the possible range of observation. Elsewhere on the line, outside of the terminal and tunnels, this form of signal would not prove satisfactory because of the higher speeds and longer range of observation required. The semaphore is used, therefore, on the open line.

The track circuits are operated on alternating current, using double-rail return with induction bonds on the main line and in the tunnel, and single-rail return in the three yards. The electro pneumatic interlocking machines have lever lights and illuminated track models, and train describers, telautographs, telephones, telegraphs and train starting system instruments are all provided in the station yard towers. The pneumatic power is obtained from the Thirty-first Street service plant, relayed by compressors. The electric power is single-phase, 60-cycle alternating current, distributed at 2,200 volts from a special switchboard in the service plant.

There are transformers located in the towers and at signal locations which step this current down to 220 volts for local circuits, to 130 volts for track circuits and to 55 volts for signal lights and other alternating current apparatus. Motor generator sets in each tower supply 25-volt direct current for operating direct current relays and electro-pneumatic valves. Storage batteries charged by motor generator sets maintain the constancy of this current supply.

In cabin "A" there are 900 relays, and the total number in all the cabins is 2,600, while the total length of signal wire used in this installation is about eight million feet.

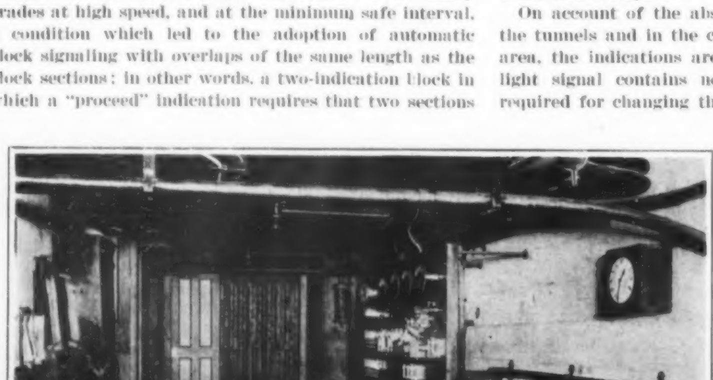


Fig. 3.—Electric Equipment in the Basement of Cabin "A."

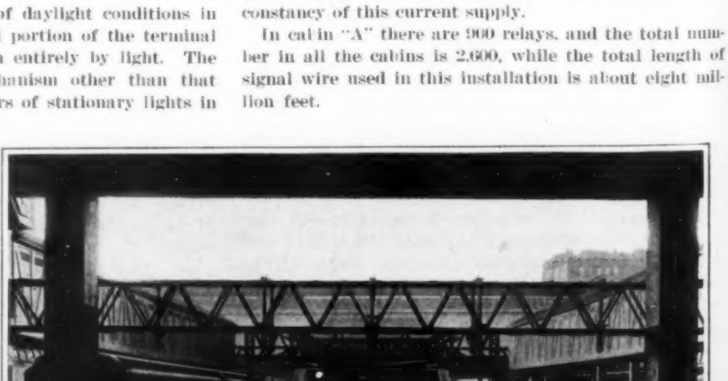


Fig. 4.—View Looking West from Cabin "A."

An Easily Constructed Tesla Coil

Instructions for the Amateur Electrician

By Allan S. Dana

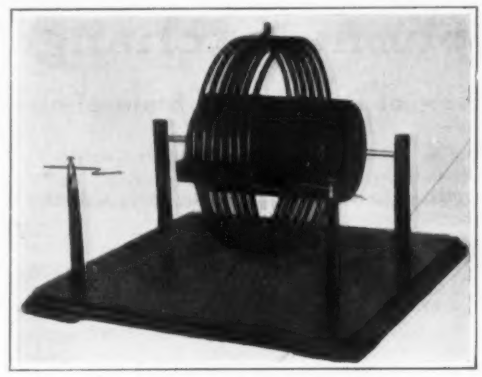
The special advantage of the Tesla coil, here described, is that it is comparatively small and light. Therefore it can be readily carried from place to place. Most Tesla coils are immersed in oil but this is objectionable as the oil leaks or slops over, and also greatly increases the weight of the instrument. Although the oil-immersed coil is more efficient, a Tesla coil in air is more convenient and only slightly less efficient. The air Tesla coil to be described has the same advantage that a coil in oil has—that of having a fluid insulator between the primary and secondary coils, so that, if a spark passes accidentally between them, the air or oil immediately fills up the gap made by the spark. A solid insulator cannot be used because one spark between the primary and secondary would make a hole in the insulating material and the spark would easily travel through this hole thereafter. Hence a coil should be in either oil or air. But if it is to be portable, air must be the insulator.

Using this coil with a 4-inch induction coil, it gives a 5½-inch spark. This is the longest spark possible with this instrument, because the spark has to travel only a little over 5½ inches to jump from the primary to the secondary coil. Hence, if the rods where the spark discharge is supposed to take place are separated by more than 5½ inches, the spark will not jump there, but will take the shorter path to the primary coil.

The base of this coil is a piece of 1-inch whitewood, 16 inches by 15 inches, with its edges molded. Two and one-quarter inches from the front and 12⅝ inches apart bore two holes which will allow an 8/32 machine screw to pass through. Again, bore two holes of the same size 10 inches from the front and 12¾ inches from each other. Also two holes of the same size 10 inches from the front and 3¼ inches apart. Screw four rubber tips, such as used on furniture to avoid scarring polished floors, to the under side of the base board at the corners. These will keep it from scratching polished tables. The base may now be painted. A black varnish gives a good finish.

Next, wind six turns of No. 2 copper wire around a circular form so as to make a coil 10 inches in diameter. At each side of the coil, place two pieces of ½-inch oak, 1 by 4 inches, which are supplied with machine screws and nuts, and clamp the wires 3/16 of an inch apart by means of these. The machine screw heads should be toward the inside of the coil and must be countersunk until flush. At the bottom of the coil another strip of oak is used to clamp the whole coil to the base by means of machine screws passing through the oak strip and the holes already bored in the base board. This oak strip should be of ½-inch oak, 1 by 4 inches, with two holes for 8/32 screws, 3¼ inches apart. Flatten the ends of this primary coil and bore in each a hole which will allow the binding post from the carbon of an old dry battery to be put on and used as a terminal of the coil.

The secondary coil is wound on a cardboard tube 4¾ inches in diameter and 7¼ inches long. Cut two disks of 3/8-inch wood to fit tightly the ends of the tube and bore a ¼-inch hole in the center of each disk. Mount the tube so that it can be revolved and wind, side by side, a No. 36 single cotton-covered copper wire and a thread of 100 cotton, which has been soaked in paraffine and allowed to cool. In this manner the entire surface of the tube is covered with a coil of wire, whose adjacent turns are separated by the thickness of the paraffined thread. To the ends of this coil 10-inch lengths of No. 28 or No. 30 copper wire are soldered, and melted beeswax poured over the joint to hold it fast to the cardboard tube. Shellac the entire coil of wire, applying two coats of thin shellac. When this has dried, unwind the paraffined thread and give one



General View of the Tesla Coil.

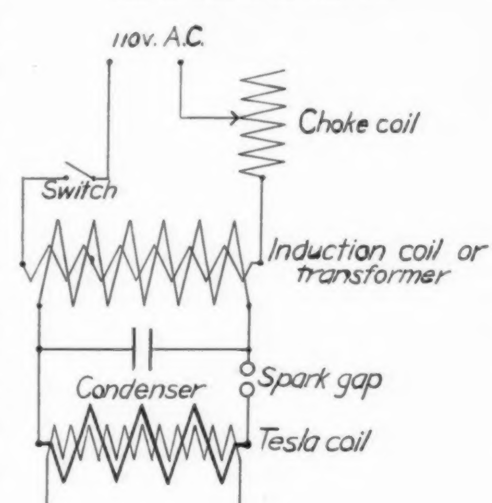


Diagram of Connections for Fitting up the Tesla Coil.

or two more coats of shellac to hold the wire onto the cardboard tube. Be sure that no two turns of the coil touch. Every turn must be separated from the next one by the width of the paraffined thread. When this is dry, pass a ¼-inch glass rod, 12¾ inches long, through the holes in the wooden disks in the end of the cardboard tube.

From a ¾-inch hard rubber rod cut two pieces 6 inches long. In one end of each bore and tap a hole for an 8/32 screw. One inch from the other end bore a ¼-inch hole half way through the rod. These last holes are to hold the ends of the glass rod, which passes through the center of the secondary coil and is used to support it. By 8/32 machine screws passing up from the under side of the base board through the holes already bored 12¾ inches apart and 10 inches from the front, these hard rubber rods are held to the base and, in turn, support the glass rod which carries the secondary coil.

Cut two 5-inch pieces of ½-inch hard rubber rod, and bore and tap each end for an 8/32 screw. At one end of each rod a binding post is screwed on, while a screw passing up from the under side of the base holds each rod perpendicular to it.

Then the ends of the secondary coil are connected to the binding posts on the top of the hard rubber rods.

The coil is now complete. If used with an induction coil on alternating current, it is best to screw the vibrator up tight, so that it will not work, and use a choke-coil in the primary circuit in order to cut down the current. Still better, a high voltage, closed core transformer, such as used to send in wireless telegraphy, may be used. The terminals of a medium-sized glass plate condenser are connected to the secondary terminals of the transformer or induction coil. Then one terminal of the transformer or induction coil is connected to one end of the coil of large wire on the Tesla coil. The other end of this coil of large wire, or primary coil, is connected to a spark gap, and the other end of the spark gap to the other end of the transformer or induction-coil. When the current is turned on and the spark gap and condenser regulated, a harmless 5½-inch spark will jump between wires placed in the binding posts to which the ends of the secondary of the Tesla coil are connected.

A great many experiments may be made with this coil. Geissler tubes can be lighted by holding one end of the tube in the hand and presenting the other end to one terminal of the Tesla coil. When this is done, the electricity which lights the tube passes through the person and still does not cause any sensation. But in these days of wireless telegraphs and telephones, the most interesting experiment from the layman's standpoint is a wireless light. To make this, bend 4 feet of No. 14 B. and S. insulated copper wire to form a circle and connect a 2-volt battery lamp to the ends of this coil. If this coil is then moved near to the Tesla coil while it is in operation, the lamp will light, provided, however, that the primary coil of the Tesla and the coil of the wireless light are in the same or parallel planes.

Many other experiments can be carried out by means of this simple Tesla coil.

A Passenger Cableway on Mont Blanc

Tourists will soon be able to make the ascent of Mont Blanc by the aid of a suspended railway now in the course of construction, of which we publish illustrations herewith. This is the second cable line of its kind to be installed in Europe, a similar cableway having been built some years ago on the Wetterhorn, as described in the Scientific American of May 8th, 1909.

Near View of the Car.

View Showing Two Towers and a Span of Cable.

The new cableway differs in several points from the Wetterhorn railway. It starts from Chamonix at the level of the valley, and is to be built in a number of sections, running first from Chamonix up to the Bossons glacier, and thence to the lofty peak of the Aiguille du Midi, which is situated at an altitude of 12,608 feet.

A suspended cableway is very much cheaper to build than any other type of mountain railroad, a point which is of particular importance in the present case, as the traffic over such a line is necessarily very limited. The car is suspended from a rolling carriage traveling upon the main carrying cable, shown uppermost in the figure.

A traction cable runs over drums at the upper and lower stations, its end being attached to the car. The main supporting cable is strung from structural iron towers, braced 130 to 300 feet apart. The space between the towers is greater where the slope of the mountain is steeper, and in one place a very long span of 660 feet occurs. There are two supporting cables, one for the up-going car, and a parallel cable, 12 feet distant, hung from the same towers, for the car going down. As in the usual type of cable lines, the traction cable is made endless and works both cars at once, passing over sheaves at the terminal stations.

The car has accommodations for twenty-four persons, and is suspended from an iron framework, with two pairs of rollers at the top, which travel upon the supporting cable, while the traction cable is attached to the lower part of the framework. Between these two cables is an emergency rope, which is provided in case the traction cable should be ruptured. This duplicate cable runs over drums at the terminal stations, like the regular cable, but is not ordinarily attached to the car, though it can be gripped at any instant by means of a brake provided expressly for this purpose. The gripping mechanism is automatic, and is brought into play immediately upon the rupture of the regular traction cable, the weight of the car serving as the agent for actuating the brake.

The power is supplied by an electric motor at the lower station, and four different brakes are installed, to make every possible provision against accident.

It is expected that the line will be running as far as the Bossons glacier by next year, and the rest of the road is to be completed later.

In view of the rocky character of the land, it would have been difficult to build any other kind of a line than a cableway without incurring very heavy expenses.

Three large tourist hotels are to be built on the slope of Mont Blanc in connection with the new cableway, and there can be little doubt that the line will enjoy the extended patronage of numerous tourists passing through the Chamonix region.

Automatic Telephone Exchange Systems—III.*

A Survey of the Present State of the Art

By W. Aitken

Concluded from Supplement No. 1881, page 40

The opinion is commonly held that the automatic system is most inflexible, but quite the contrary has proved the case in practice, and all special services, such as metering or registering calls, party line working, private branch exchange working, etc., are now standardized. On a message rate system the meters are associated with the line switch as already described. It will be readily understood that a free service may be given to the information and other desks, or to any special departments, by not fitting them with the battery reversing facilities, and for this purpose these lines are grouped on special connectors.

Party Line Working.—A 4-party frequency system is used with the bells of the subscribers' instruments tuned to respond to frequencies of 16⅔ cycles, 33⅓ cycles, 50 cycles, 66⅔ cycles. A group of party lines will be multipled over four connectors, and to each connector will be supplied ringing current of one frequency only so that when a connector is brought into use only one particular subscriber on the line can be called.

Private Branch Exchanges.—These may be entirely automatic, but are usually preferred to be manual for local service. A switchboard will have several lines to the central exchange, and these are given one number only. These lines are joined to special connectors which have a feature belonging to the selectors that enables them to continue to rotate automatically until a free or disengaged line is made contact with. The connector is made to rise and rotate to the number of the line in the usual way by rotating the dial twice, then if the first line associated with that number is engaged the shaft will continue to rotate until a free line is obtained, or, if all are engaged, then it will go to the contact beyond, which is associated with that group of lines, and is connected up to give the busy signal, so that the subscriber hearing this knows that all lines are engaged.

Call Offices.—These are operated in a simple but very ingenious manner. The subscriber calls in the usual way, but when the called station answers, the reversed current actuates an electromagnet in the coin box which short circuits the microphone and places a shunt about the receiver, so that the caller can but faintly hear the party called. On the insertion of the requisite coin the talking is made normal.

Sub-District Stations.—As already indicated, a great feature of the automatic system is that it is not essential to concentrate a great number of lines in any one building. The system will work as efficiently if 10,000 lines are in one building as in ten exchanges of 1,000 lines each. The apparatus, with the exception of, probably, the power plant, will be exactly similar, but the street cable plant will be very different. Instead of 10,000 lines converging to one center, there will be, in addition to the shorter converging lines, the 10 per cent of lines between first and second selectors between exchanges. It will thus be seen how efficiently the automatic system meets the varied needs of a great city, where a residential district of a few years ago with few telephones becomes a busy business center, requiring many telephones, like Finsbury Circus; or when a slum, like the district between Holborn and the Strand, gives place to a great thoroughfare like the Kingsway, and thus upsets all calculations of capacity in underground mains and necessitates the re-opening of streets. In the automatic system a district station of suitable capacity would be opened in such localities and the necessary local lines concentrated on these, and the existing cables of small capacity to the large exchange would be utilized as junction wires.

*Paper read before the Institution of Electrical Engineers, London, England.

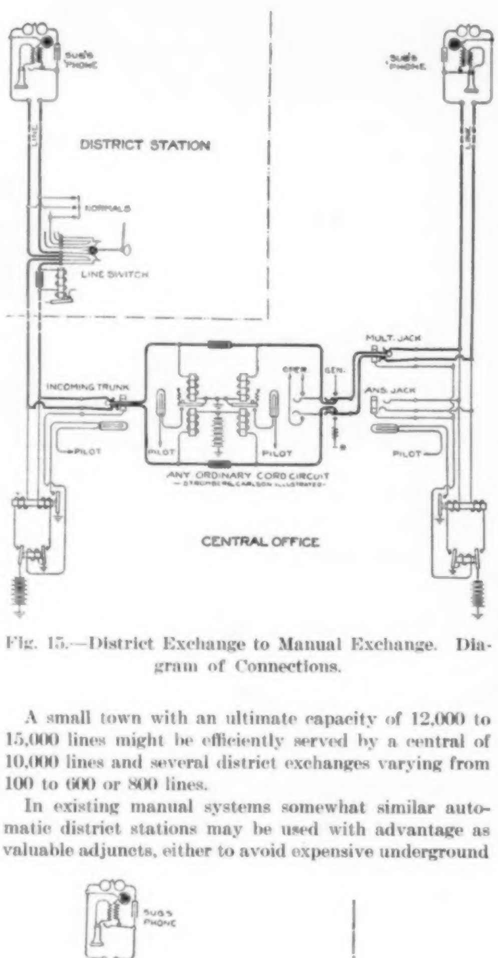


Fig. 15.—District Exchange to Manual Exchange. Diagram of Connections.

A small town with an ultimate capacity of 12,000 to 15,000 lines might be efficiently served by a central of 10,000 lines and several district exchanges varying from 100 to 600 or 800 lines.

In existing manual systems somewhat similar automatic district stations may be used with advantage as valuable adjuncts, either to avoid expensive underground cable work, the provision of new manual plant, or expensive additions to existing plant of limited capacity, and this phase of working deserves more than passing attention. The instruments on such an automatic equipment would be of any of the well-known patterns without any automatic feature whatever. At the district station they would be connected to line switches, such as have already been described, for outgoing work. At the manual exchanges these junction lines would end on the usual line and cut-off relay, answering jack, and calling lamp, or on single cord equipment like manual incoming junctions. On the removal of the receiver to call, the line switch would connect with a disengaged junction instantly, and the line lamp would glow, and the operator would complete the connection in the usual way, the service being absolutely similar to a connection in a purely manual exchange. Fig. 15 shows such an arrangement. For outgoing calls from the manual exchange, an operator would have in addition to the ordinary double cord equipment, a switch to connect up a dial calling device by which, after making the connection, she would call the number required in a manner similar to a subscriber calling on a full automatic system. All the lines in the district station are multiplied on to connector banks to allow of them being called. Fig. 16 shows such an arrangement. This method supposes a complete multiple of the manual exchange to be available. Another method is to multiple the outgoing junctions over the manual board and on to a controlling operator's position which may be away from the multiple. This operator would have a key in each junction to switch in the dial-calling device and a lamp to indicate what lines were engaged. A manual operator receiving a call for a district station number would momentarily connect her telephone to a call or order wire, and inform the control operator the number wanted. That operator would allot a junction to which the manual operator would make connection. The controlling operator would call by the dial and ring the

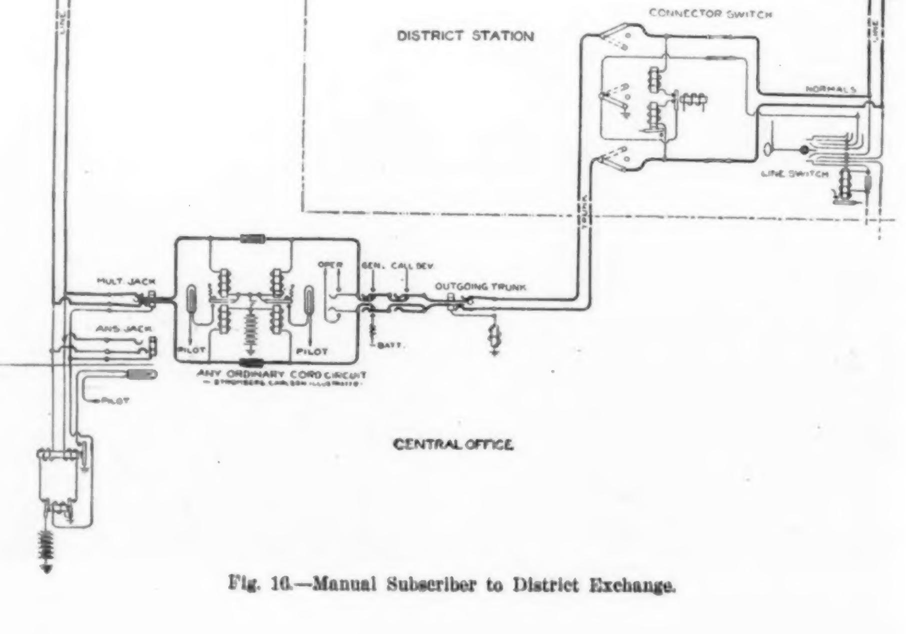


Fig. 16.—Manual Subscriber to District Exchange.

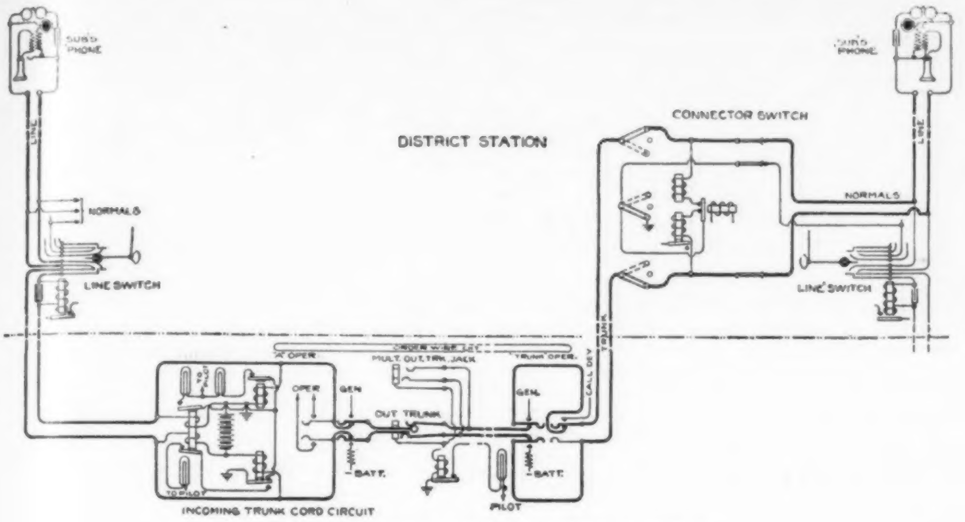


Fig. 17.—Connections of Automatic to Manual Stations.

subscriber wanted, and the manual operator would supervise the connection by the cord lamps in the usual way. That withdrawal of the plugs after the clearing signals were obtained will give the signal "junction disengaged" to the controlling operator and automatically restore all apparatus at the district exchange to normal. Fig. 17 shows such an arrangement. It will be readily understood that two district station subscribers can be connected together by the circuits already described by the use of two junctions, one incoming and one outgoing.

Such an important and far-reaching subject as a change from a manual to an automatic system must be considered very seriously from various points of view.

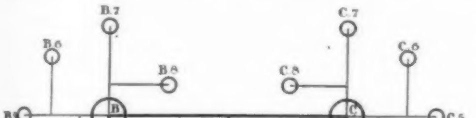


Fig. 18.—Skeleton of Divided 50,000 Line Automatic System.

In some countries objection has been raised to the automatic system because it will do away with one form of employment which is very suitable for women; in new countries where women are scarce the automatic appeals as a way out of a great difficulty. Considering the question, however, quite apart from sentiment, it will be interesting to investigate it, briefly and generally, from the points of view of efficiency, capital cost, and maintenance.

Efficiency.—The manual system is now as near perfection from an operating point of view as it can be brought, and increased efficiency can only be obtained by refinements due to more expert operators and thorough supervision. The principle of working is that the subscriber should only remove the receiver, state his requirements, and replace the receiver on the switch-hook, all operating beyond being performed by experts. This sounds good and simple, but it depends, firstly, on the articulation of the speaker, who may be from any county or any country, and, secondly, on the ear and understanding of the operator to interpret the words before giving effect to them. Again, in a city like London, something like 75 per cent of the calls are over junction lines, which means that the first operator has to repeat the number required to a second operator. In the automatic system the responsibility for getting any number, no matter how large, is entirely on the caller. If a blunder is made, the caller has only himself to blame. He is practically asked to spell out his number like a child with picture blocks, and yet some experts say he is not to be trusted to do this. Why, one has seen a horse do as much! It is also claimed that the subscribers on an automatic system answer more quickly, as there is no operator to blame. For rapidity of service **the automatic has the advantage unquestionably. As** quickly as a caller can spell out his number, so quickly is the connection built up, *for any number on the system*, and the clearing is instantaneous. The time taken to send in a clearing signal on the manual is the time taken on the automatic to disconnect. The secrecy of the conversations will also appeal to many.

Capital Cost.—This for the actual exchange equipment in small exchanges is much more with automatic than with manual, but as they increase in size they approach nearer until at about 100,000 lines they are equal in cost. This is for single exchange equipment, but when the telephoning of a great city is considered, the results may be very different. The subject is, however, a very complex one, and would require very careful study of a particular area to determine exact costs. This may be noted, however, that whereas the manual system increases with an ever-increasing ratio owing to the increase of junction lines with their complicated circuits, huge multiples, and attendant operators, the cost of the automatic system increases much more uniformly. The apparatus increases on the percentage basis, formerly mentioned, and the junction lines are actually fewer, as they carry a greater number of busy-hour calls owing to the rapidity of the service.

Owing to the tendency on the manual systems for junction lines to increase abnormally, as great a number of lines as possible are accommodated in one exchange, and the average length of the subscribers' lines is, therefore, increased. On the automatic system, however, as the working from beginning to end is junction working there is not the same necessity for large exchanges, and the apparatus can, therefore, be broken up and distributed in groups of moderate size as best suits the economical lay-out of an underground cable system. The average length of the subscribers' lines will be, therefore, much less. Fig. 18 shows a suggested or typical lay-out by Mr. W. Lee Campbell. Centrally and at each of the corners of a square are five main exchanges with numerous smaller exchanges connected with each. The line switch and first selector for an outward call from one of the smaller exchanges would be in that office, the first selector would then pick out a second selector in one of the main exchanges, then, if another sub-exchange was wanted, the second selector would pick out a third selector in that exchange, which, in turn, would pick out the correct connector on which the number wanted was located. The operating would be exactly the same if all the lines were in one building.

Fig. 19 shows an actual lay-out (at Los Angeles) and attention is drawn to the length of the lines between exchanges.

The figures obtainable regarding costs are very few, and they are based entirely on American practice. Mr. W. Lee Campbell (in his paper before the American Institute of Electrical Engineers, June 29th, 1908) showed by a series of curves the comparative costs of manual and automatic equipments, and as these have not been challenged they may be taken as at least comparatively correct. Since that time the manual system has increased in cost by the introduction of new features, as the use of three calling lamps and jacks per line, the more general introduction of keyless ringing, etc., but **against this the manufacture of equipment is somewhat cheaper.**

In the automatic equipment the introduction of the secondary line switch to reduce the number of first selectors, the use of the same switch to reduce the number of junction lines, the introduction of secondary line switches with banks for a greater number of circuits than ten, has greatly reduced the cost of automatic plant, and particularly the number of underground junction lines to carry the traffic between exchanges.

The cost of installing, both manual and automatic equipments, will be greater, I think, in this country than in America.

The following schedule of comparative costs for manual and automatic exchanges of 5,000 and 10,000 lines are taken from the paper referred to.

The cost per line of the manual exchanges given are low if ancilliary lamps are used.

If we compare the Standard British common battery telephone instrument with that used by the Automatic Electric Company, the latter will, probably, be found cheaper, but that would be comparing things very different. The woodwork of the former is much more

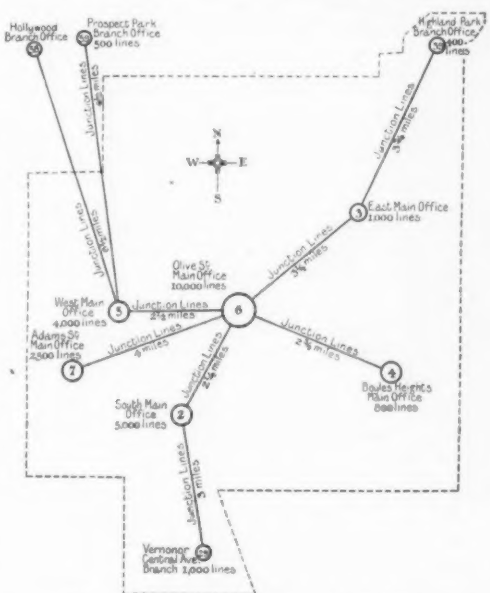


Fig. 19.—Plan of Los Angeles System.

elaborate, and in the latter there is no induction coil, an electromagnetic receiver being used in series with the microphone. The dial switch is of a very simple, yet efficient form.

The transmission efficiency of the two instruments is at least equal, and on a system using entirely the Automatic Company's circuit, the latter would probably be found more efficient.

It will be noticed that the increased cost of automatic equipment is more than counterbalanced by the reduction in cost of building, the cubic space necessary being only half of that required for a manual equipment. The cost of a fireproof building, as given, is very low, 0.9 cent per cubic foot, but an automatic building need not be so ornate as a manual and need not occupy such a valuable site.

The manual system is seen at its worst when subdivision takes place. Owing to the cost of line equipment it is not economical practice to concentrate all lines on one large central exchange, even when this could cope with the requirements of a town. It is usually advisable, therefore, to have district exchanges, and the schedule shows the results when 10,000 lines are divided between two 4,000-line and two 1,000-line exchanges. The number of operators necessary is greatly increased. Owing to junction work the *A* operators' load is reduced from, say, 240 calls per busy hour to 115. *B* operators have to be introduced for work between exchanges, and the total operators will be increased from about 90 to

Comparative Costs—Manual and Automatic Systems.

	5,000 Lines.		10,000 Lines.	
	Manual.	Automatic.	Manual.	Automatic.
Value per line—switchboard equipment without junctions	$17.85	$20.75	$25.00	$25.00
Subscriber's instrument	8.75	11.25	8.75	11.25
Cubic feet of building	42,000	21,000	88,000	44,000
Square feet floor space	3,700	2,100	7,250	3,750
First cost fireproof building (land, furnishings, office not included)	8,335.00	4,275.00	17,500.00	8,750.00
Operating, repairs, maintenance, per line per annum	6.25	2.20	8.35	2.35
Above plus power, light, taxes, depreciation equipment and building renewals (depreciation of manual taken at 10 years; automatic at 12 years)	10.25	6.00	12.50	6.35
If manual divided into two exchanges of 4,000 lines and two of 1,000 there will be 115 A operators, 25 B operators, instead of 90 A operators.				
Cost of operating and maintenance of above per line per annum			17.50	6.60
Cost per line, switchboard equipment per annum			23.50	24.50
Cost per line, switchboard equipment and buildings per annum			26.10	25.50

140. The cost of buildings will also be much greater. The automatic equipment will not be increased seriously, the cost for power plant will be greater, the cost of buildings will not be so serious as with the manual. But with the automatic the efficiency will remain the same as if concentrated in one building, while in the manual the service will be appreciably slower, and the liability to wrong connection much greater owing to the repetition of numbers, etc.

It is a very difficult matter to deal with the saving effected in conduits and cable for lines, unless a particular town be laid out for each system; but, generally, I think, it must be conceded that as the service remains always at 100 per cent efficiency, no matter how the units are distributed, there must be a great saving, owing to the possible reduction of the average length of the subscribers' lines, the reduced number of junction lines, owing to their greater carrying capacity under automatic conditions, and to the greater flexibility due to the feasibility of opening an automatic exchange, owing to the growing telephonic density of a district, whereas a manual exchange could only be opened at the cost of reducing the efficiency and increasing the operating cost of the whole area.

The cost of buildings is very much less on an automatic system as the equipment is much more compact—no kitchen, rest-room, and other conveniences for operators are necessary. The furnishings, decorations, electric light fittings, are much simpler.

Maintenance.—All operators' expenses are saved except such as are required for trunk service, information desks, and the like. Against this, of course, has to be placed the cost of electricians or mechanics. One good man is usually provided for every one thousand lines. Many of the sub-exchanges have no regular attendant, all lines being tested from the nearest main office, and charging of accumulators being over wires from the main exchange, periodical visits only being paid to see that all is in order. Fig. 20 is a plan showing

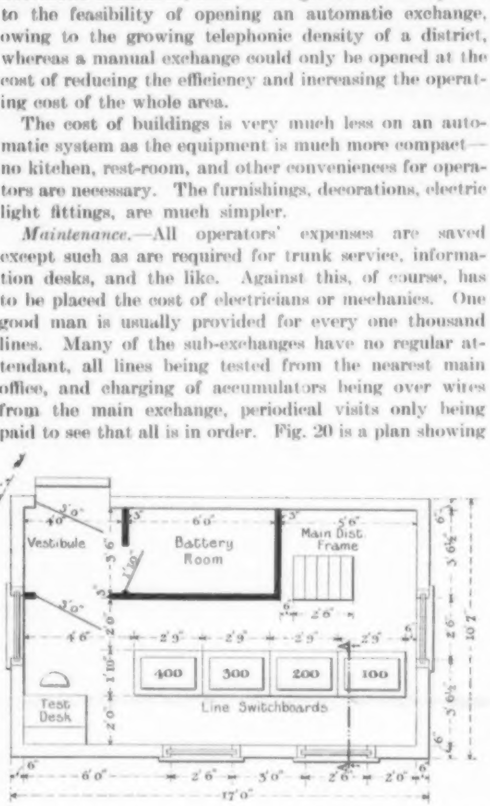


Fig. 20.—Floor Plan of Building to House District Station of 400 Lines.

the general arrangement of one of these buildings. The renewable parts are very few, practically only the wipers wear out after many years' use. In the manual exchanges cords and plugs are a serious annual charge, lamps burn out, and answering jacks may have to be renewed.

The Automatic Electric Company have lately published a certificate over the signature of the President of the Citizens' Telephone Company, Grand Rapids, that the cost of replacing parts, due to defective workmanship, or material, or ordinary wear and tear, during seven years, amounted to \$962.62, an average of \$137.52 per annum, or 1.8 cents per line per annum, for the average of 7,500 lines in service. This sum included all central equipment, except power plant, and also the dial switches in the telephones.

Similar data for manual equipments is not readily available. From figures obtained in connection with the Chicago manual system the average cost of repairs on central equipments and instruments is about \$6.75 per line per annum, the cost of repairs on exchange equipment alone averaging about \$4.25, the figures ranging between \$1 and \$10, depending whether the lines were quiet or busy ones. For Seattle the figures are given as \$2.50 per line per annum, line and exchange equipment, and \$2.50 per subscriber's instrument. It would be interesting to hear what the costs of repairs are in this country, and further figures regarding automatic equipments.

Semi-automatic systems have been suggested as meeting the requirements of future development, but it is very doubtful if they can be made an economical success. In a proposition put before the last Paris Congress of Government Engineers, a system was described in which the operating, so far as the subscriber is concerned, remains as at present, but in which the *A* or answering operators have calling devices by which the *B* or connecting operator is eliminated. This has already been done by the "Clement Auto-manual" system, and is quite workable, and great claims are made for rapidity of service. The only advantage seemed to be that the repetition to the second operator is omitted. The calling subscriber may still send in his call slowly and nearly inarticulately; the operator has to spell out each number wanted by keys or dial.

Semi-automatics seem to me to be good only as a transition measure. The "Traffic Distributor" system of the Automatic Electric Company meets the requirements in an efficient manner. In this the multiple of a manual exchange is retained, but the answering jacks, calling lamps, line and cut-off relays, and intermediate distributing frame are omitted. The keyboard equipment is simplified in that, instead of double cords, only as many single cords are provided as the operator can attend to. From the main frame, lines in parallel to the multiple, are carried to Keith primary line switches with their 10 per cent of lines to secondary line switches, so that the number of lines is reduced until they are just sufficient to carry the traffic (in the manner already described for junction working). These lines are then distributed among as many operators as are necessary to cope efficiently with the work, the lines ending on the single cords already mentioned. Switching devices are introduced, so that position after position may be thrown out of use, and the work therefore concentrated so that it can be dealt with in the most economical and efficient manner.

It is to be noted particularly that the calls are distributed in rotation to the different operators, so that all have an equal amount of work to perform.

The instruments at the sub-stations are exactly the manual common battery instrument, and the subscriber calls by lifting the receiver. Immediately the line switches act one after the other and extend the line to the plug and the lamp associated with the plug glows. (Meantime the master switch has moved all lines of a group to the next spare circuit to the next operator so that the line is pre-selected.) The operator pulls over the speaking key to answer, lifts the plug, tests and completes the connection in the usual manner.

Time does not permit the subject of automatic telephony being dealt with exhaustively. The Lorimer, the American Automatic Company's, and other systems would require another paper to deal adequately with them. That there is a great future before automatic telephony I am convinced, and my paper can only be looked on as preparing the way for more detailed consideration of the subject.

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Large Glass Sand Deposit

FOR a distance of over 25 miles along the tracks of the Virginia & Southwestern Railway in southwest Virginia is exposed a deposit of exceptionally pure and hard white sandstone known in the United States geologic folios as the Clinch sandstone. Beginning at Mendota, on Clinch Mountain, this great deposit stretches along the railroad, crossing it at Mocassin, and lying always within one to two miles of the right-of-way. The deposit varies in thickness from a few feet to 500 feet in many places.

About one mile west of the town of Mendota this sandstone is at present being quarried on top of the mountain. The product is conveyed to the railroad by means of an incline, the empty cars being carried up the slope by the descent of the loaded ones. At the railroad it is crushed into fine sand and pulverized by a mill. Water power is plentiful in the section and costs practically nothing.

Analyses of the sandstone at this point shows the pure silica content to be from 99.64 to 99.75 per cent of the rock. On account of this exceptional purity this should be an excellent grade of glass sand, and, on account of its whiteness, a fine material for the manufacture of sand lime brick.—*The Southern Field.*

Materials for Paper Money

THE materials that go to make our paper money are gathered together from all parts of the world. Part of the paper fiber is linen rag from the Orient. The silk comes from China or Italy. The blue ink is made from German or Canadian cobalt. The black ink is made from Niagara Falls acetylene gas smoke, and most of the green ink, mixed in white zink sulphite, is made in Germany.

The red color in the seal is obtained from a pigment imported from Central America.—*Engineer's Souvenir.*

Science Notes

Temperature Regulation of the Body.—In an article in *Cosmos*, A. Acloque discusses the various means by which warm-bloooded animals regulate their temperature Particularly in the case of man it is observed that, in the first place, the amount of food ingested varies with the season, the appetite being keener in winter than in summer. In consequence of this, a greater amount of heat is developed by the oxidation of food material during cold than during warm weather. In addition to this, the absorption of oxygen is in winter increased by more active and deeper respiration and by increased muscular activity. Under the influence of cold the naso-constrictor nerves cause the superficial blood vessels to contract, thus reducing the area of warm blood exposed to the cold outside temperature, and thereby diminishing the loss of heat by radiation These are physiological effects, outside of the control of our will. They are, of course, supplemented in civilized man by reasoned actions in the choice of suitable clothing and shelter. In the case of animals, this latter factor is to some extent replaced by special physiological provisions, such as the growing of a special winter coat. As regards the opposite aspect of temperature regulation, namely, the provision against undue heat, there are also a number of expedients by which the organism meets the demand of the situation Among these is perspiration and evaporation of water from the surface of the lungs. Such evaporating moisture absorbs, in the process of evaporating, its latent heat, which is thus withdrawn from the organism The secretion of perspiration may amount to as much as 400 grammes (12 ounces) per hour. This secretion is regulated outside of the control of the will by the vasomotor nerves The amount of moisture emitted by the lungs varies from 300 to 600 grammes per hour. About 15 per cent of the total energy liberated in the organism is on an average, excreted through this channel. The respiratory rhythm is accelerated through nervous mechanism as the temperature rises. This gives rise to a condition known as thermic polypnœa. This phenomenon is not very obvious in the case of man, but everyone is familiar with it, for instance, in the dog, panting on a hot day or after a brisk run.

Why Lobsters Turn Red.—Lobsters and crabs when alive are of a plain dark gray color; in boiling, however, this changes to a bright red, as is well known. This change takes place only in the uppermost layer of the shell. Under the transparent cuticle there is hidden a layer of pigment composed of red, brown, yellowish and bluish green particles. They produce the general color as well as the pattern on the shell of the lobsters. The red pigment is more stable than the bluish green; the latter is destroyed by boiling water, thus bringing out the red pigment. There are other causes too which may destroy or bleach the bluish-green pigment. This also explains why the dead animal gradually turns red or at least assumes a pale color.—*Neueste Erfindungen.*

Preserving Hailstones.—According to a news report, Prof. Boris Weinberg has erected a cabin in Tamsk, Siberia, where he expects to study the formation and nature of hailstones. This cabin has double walls which are fitted with a mixture of ice and sulphate of copper. The temperature within this hut can be kept below zero for a considerable time, and here Prof. Weinberg preserves and studies the hailstones which are collected during a storm. Of all places he selected Tamsk, in Siberia, where he expects to work at leisure and without risk of losing the hailstones by melting. The formation of the hailstones during the hottest season of summer, their peculiar, compact globular form, and especially their great size have never been satisfactorily accounted for. Prof. Weinberg cuts these hailstones into thin slices, which are photographed on autochrome plates under the polarizing microscope, as it is done with anatomic preparations. In the structure of the globules he expects to find the secret of the mode of origin of hail.

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